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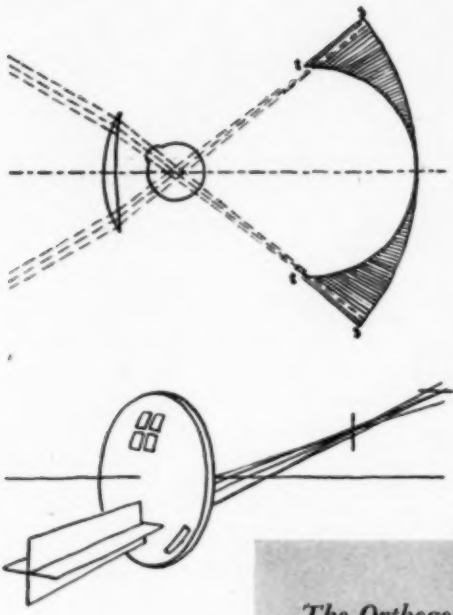
CHROMATIC ABERRATION • SPHERICAL ABERRATION • COMA



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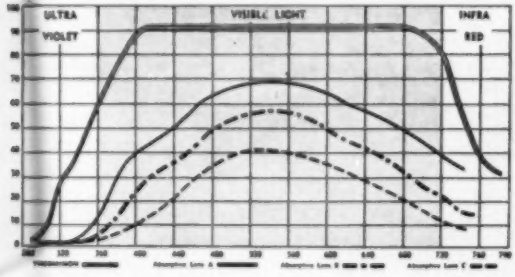

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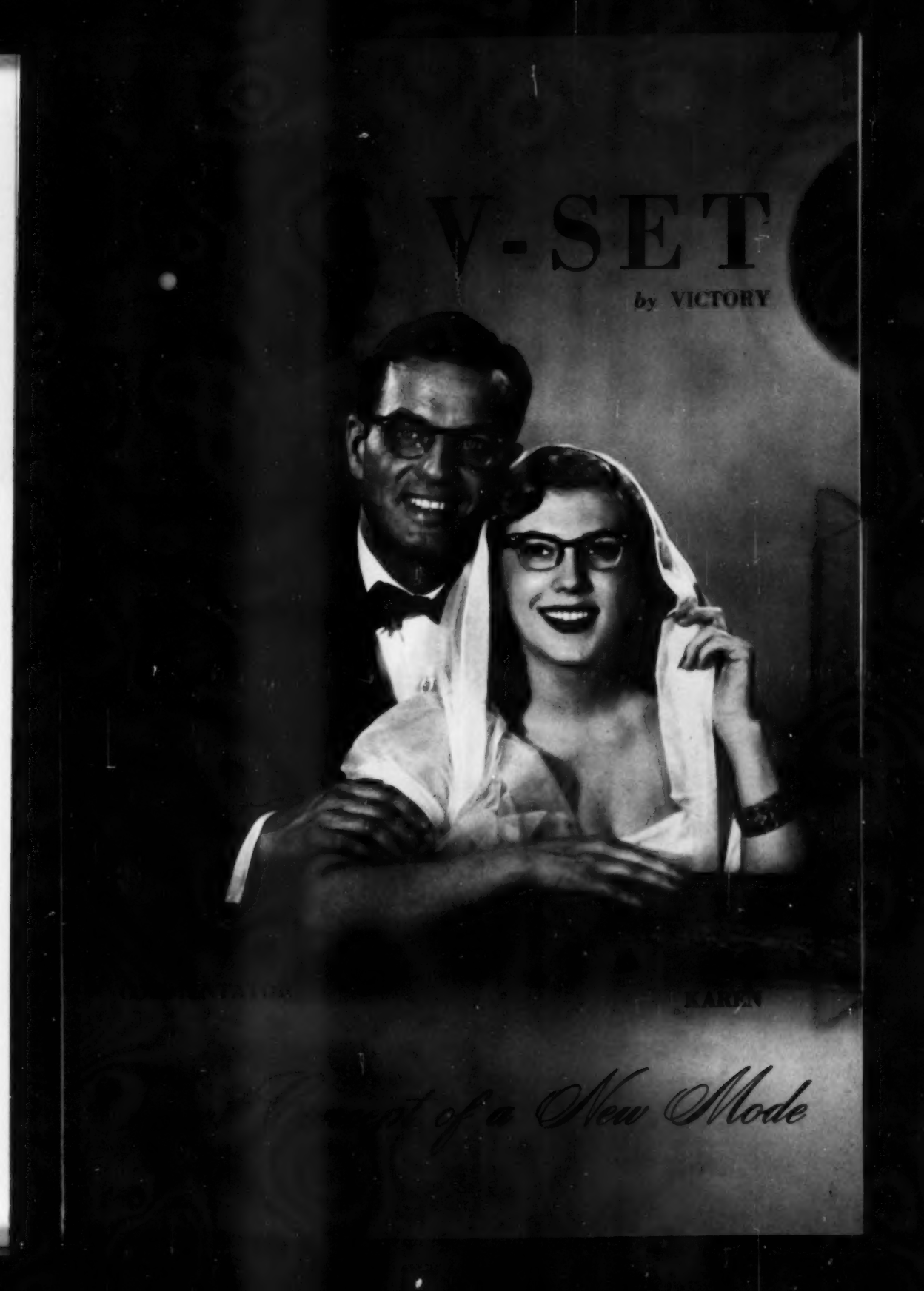
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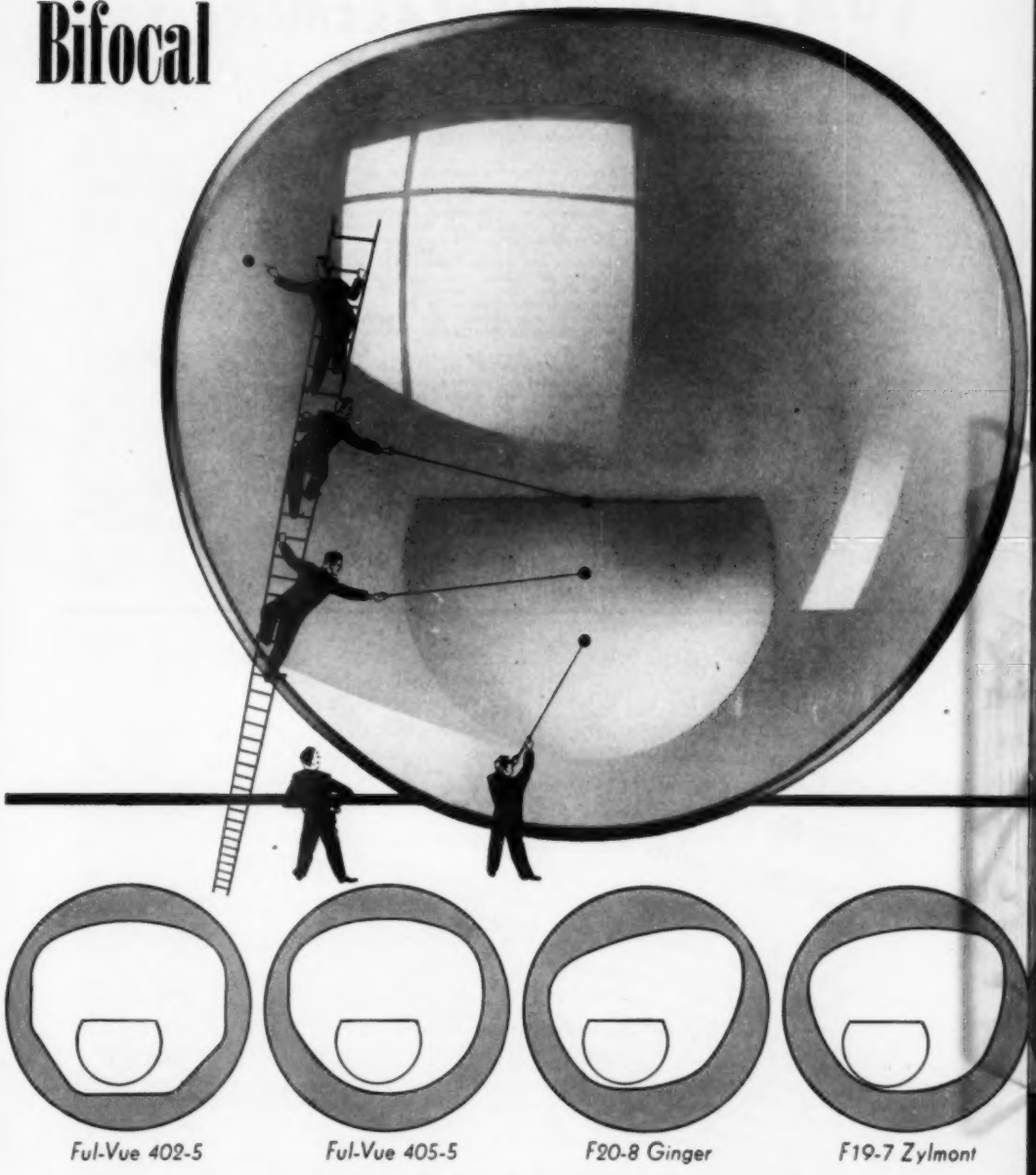

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Diagrams illustrate how new large size blank accommodates most modern shapes and affords enough decentration for practically all Rx's.

JUMP OR DISPLACEMENT ?

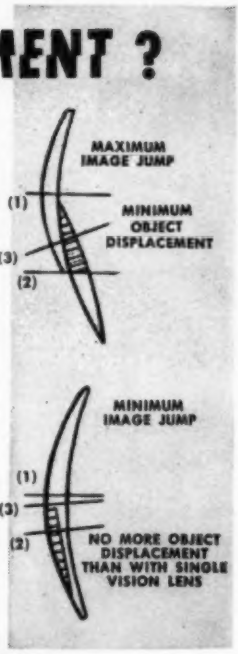
Three optical centers of concern in bifocals are illustrated in the diagrams. They are:

(1) The distance optical center
(2) The optical center of the segment only
(3) The resultant optical center of the combination of distance portion and segment.

The placement of (1) and (2) relative to each other controls the position of (3). Each standard segment shape has its optical center in a definite place. The positions of (2) and (3) control two important bifocal characteristics: image jump (more properly termed differential displacement) and object displacement. Image jump is a result of (2) not being on the segment's top border. Object displacement results when (3) is not at the reading level of the segment.

It is not possible to eliminate image jump and object displacement simultaneously. It is generally recognized that image jump (and co-incidental effects) is the more important factor. Modern segment shapes (flat or near-flat top types) introduce a minimum of image jump while object displacement is the same as in single vision lenses of equivalent power. It is significant that wearers of flat (or near-flat) top segments are rarely conscious of object displacement, hence this factor seldom need be considered.

Very few bifocal prescriptions permit elimination of object displacement with standard segments. When object displacement is reduced or eliminated, image jump is increased and the other advantages of the modern segment types necessary for image jump elimination are lost.



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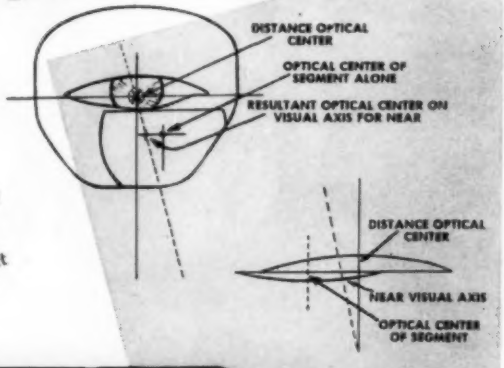
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Vol. 28 . March, 1951 No. 3

THE PROBLEM OF VISUAL DIRECTION*

PART II. THE TANGIBLE BASIS FOR NATIVISM†

Gordon L. Walls‡
School of Optometry, University of California
Berkeley, California

NEUROANATOMICAL ISOMORPHISM[1]

Those of us who are privileged to teach students of optometry at the preclinical or "basic science" level feel that the students cannot be told too much, or in too much detail, about the minute neuroanatomy and the neurophysiology of the central visual pathways, sensory and motor. Of course, we are derided for this attention to *structure*, as old-fashioned, by the optometric educators outside of the faculties of the schools of optometry. But an anatomical fact is at least something to get one's teeth into, and a visual scientist who has entered the field along the neuroanatomical route is extremely unlikely to be a phenomenologist in his cogitations over the subjective events of vision. He will exhaust first the possibilities for explaining each of them at a biological level. It is, he feels, time enough to postulate hypothetical "psychic" processes when we reach labyrinths into which anatomy and physiology extend no threads to guide us. And, it should not be lost sight of that as regards *neuro*-anatomy, the methods that make us surest of the most

*Submitted on October 10, 1950, for publication in the March, 1951, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY. Read in condensed form on the educational program of the 45th annual convention of the California Optometric Association (Santa Cruz, February 19, 1950).

†Part III of this paper, "Experimental Attacks and Their Results," will appear in the April, 1951, issue. Part I of this paper, "The History to 1900," appeared in the February, 1951, issue.

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1. "One system is said to be isomorphic with another in respect of their spatial relations if every point in the one corresponds to a point in the other and the topological relations or spatial orders of the points are the same in the two. If a system of points is marked on a flat rubber membrane and the membrane is then stretched tightly over some irregular surface, then the points in the stretched membrane are isomorphic with the points in the flat membrane" (Boring, 1942, pp. 83-4).

finely-detailed structural relationships are, increasingly as time goes on, *physiological* methods. Visual neuroanatomy, particularly, is one of the very livest of sciences. Daily, the investigators at the frontier make discoveries which are further "encroachments of the nervous system upon psychology" (an expression of Boring's—1942, p. 149). I myself used to think that neuro-physiology was bound to grow, and psychology bound to shrink, until future teachers would have trouble trying to explain what the obsolete word "psychology" had formerly meant! That is the impression a young worker in the field of vision gets.

In most other fields, he would be unlikely to hold such an idea even temporarily. Why not? Because in respect of the *non*-visual systems of the brain, the splendid ediface of "centers" for this, that, and everything, completed a century and more ago with hunches for supposed bricks and guesswork for presumed mortar, has fallen apart in these last decades like the house of cards that it was. Not that there is not a great deal of general "localization of function" left! But we know now that the *precision* of localization is in general crude. In the motor cortex, it is not individual muscle fibers, or even whole muscles that are "localized," but movements—and even whole "sets of plans" for getting a member into a particular posture, no matter what posture it is in to start with. Moreover, there is great plasticity, so that although a permanent lesion may abolish a capacity, that capacity may be capable of restoration following diaschisis, for some other part may take on the "vicarious function" of implementing the lost capacity along with its regular job.

Yes, we hear more and more today about "equipotentiality," "mass action of the cortex," and "field theory." Boring could say, in 1942, that: "Centers are already a little passé." But this (and everything in the preceding paragraph) *does not apply in the least to the visual system.* For *here*, localization is so precise and so rigid at every synaptic level as to leave one gasping. The relative spatial values of points in the optical retinal image are preserved, within limits of the order of mere *seconds*-of-arc, throughout a whole series of isomorphic subsequent images: a photochemical image in the visual-cell layer, then neurophysiological images in the bipolar population, in the retinal ganglion cells and their axons in the nerve and tract, in the lateral geniculate nucleus, and in the recording ganglion cells of the primary visuo-sensory cortex—"Area 17" in the occipital lobe. The isomorph here is relayed on out into Area 19 "to be perceived," and simultaneously a "copy" goes directly back down to mid-brain supranuclear control centers. From there still another isomorphic image is established in the oculomotor complex that plays upon the eye-muscles, so that the accuracy of the fixation reflex equals

that of the finest automatic pilots that electronic science can devise for aircraft.

Now, nothing of all this was known at the time when the problems of visual direction that we are considering here were (it is currently supposed) all solved. Helmholtz and Hering never knew the least thing about it. At the time George Stratton did his famous experiments, the most that *he* knew was that "the real organ of vision is in the occipital cortex" (Stratton, 1897). This much (or this little) had been known for about 20 years—and even *it* was still considered unproved. Even later than this, Wundt, for the purposes of his empiricism, could imagine the visual cortex to be as "adaptable" as any other cortex, and could credit it with recovery from diaschisis; and, although he knew brain anatomy as well as anyone did then, he could dismiss the whole notion of any direct connection of particular retinal points with particular visual-cortical points as "an inadequate schema still to be found here and there in the physiological text-books." (Wundt, 1902; in Titchener's translation: pp. 298-302). Wundt snorted at such neuroanatomical isomorphism—even for the visual system—as "the new phrenology," and even questioned the existence of any visual center (*loc. cit.*, p. 233).

This may seem only amusing. But it is not less than shocking to find Boring, writing *in 1942* about lesions of the visual cortex (*loc. cit.*, p. 82), and saying: "If it can ever be shown that the shape of the lesion has a definite relation to the shape of the scotoma, then the theory of visual projection would be finally established." Clearly, there is need for much wider circulation of really modern information about these matters. It should be better realized that the very permanence of a corticogenic scotoma, and the rigidity of its shape and of its localization in the visual field, is proof of an isomorphism so precise that it can mediate a native isomorphism of the visual perception and the real object. The individual unlucky enough to have a lesion in Area 17 is a scapegoat, paying a high price (with his strictly isomorphic scotoma) for the ability of the rest of us to localize visually.

The minutiae of visual neuroanatomy need to be detailed here, for they are immediately pertinent to our questions: they make it unnecessary for a strict nativist *with regard to visual direction* to feel guilty about holding a mere "faith"—they give him a concrete mechanism that he can point to, as the inborn reason for the known innateness of visual direction. The description that will follow shortly is a mere abstract of one chapter of what we teach our students about visual neurology today. Should anyone be surprised, and wonder what possible need the student, as a practitioner, will have for these fine details of information, the

answer is: probably none. He may never use the information; but, exposure to it will keep misinformation from using *him*. He is immunized against ill-advised "explanations" of the operation of the visual system at the anatomical, physiological, and even psychological levels. He may not always know what will happen or can happen in every hypothetical situation, but he will know what *may* happen and—most important of all—he will usually know what *can't* happen. He will not easily be led to expect miracles from "therapeutic" procedures based on the comforting but treacherous idea that the brain is so complex that one is free to imagine anything he pleases in the way of functional interrelationships and modes of action.

Real knowledge of the pathways from the retina through the lateral geniculate nucleus to the cortex, and from here back down to the mesencephalic supra-nuclear control centers and the nuclei of the eye-muscle nerves, began with the tremendous labors of Henschen (1890-1922, 1923, 1926), Minkowski (1911-1934), Holmes (1917-1934, 1938, 1945), Polyak (1932), and Kleist (1934). It has been greatly augmented and clarified by LeGros Clark's 20 years of study of the lateral geniculate (and the cortex). Bits and pieces—crucial bits, indispensable pieces—of information have come from the observational and experimental work of scores of others. To gain a grasp of the primate and particularly the human visual nervous system, and what goes on in it that has a bearing upon the problems of visual egocentric localization, it is only necessary to read perhaps 50 papers. Among these there are minor contradictions, that resolve themselves when one looks at the evidence, and notices dates, and remembers the history of procedures and the changing ideas of their validity.

After digesting the more recent literature,[2] it is found that we can say all this, *for sure*, about the human visual pathways:

The paramount capacity of the visual system (as compared with any other) for registering and preserving the topographical detail of the stimulus-pattern is at once predicted by the impressive fact that 38 per cent of all of the nerve fibers that either enter or leave any part of the brain or spinal cord are in the two optic nerves (Bruesch and Arey, 1942). There are about one million fibers in each optic nerve. All are

2. The "musts," for our present purposes, are: Balado and Franke (1937), Brouwer and Zeeman (1925, 1926), Clark (1932, 1941a, 1941b, 1942a, 1942b, 1942c, 1947), Clark and Penman (1934), Glees and Clark (1941), Crosby and Henderson (1948), Henderson (1949), Foerster (1931), Frantz and Vogel (1946), Holmes (1938, 1945), Köhler and Held (1949), Marshall (1949), Marshall and Talbot (1942), Talbot and Marshall (1941), Mettler (1948—the only near-reliable *text-book*), Penfield and Boldrey (1937), Polyak (1932, 1933, 1941), Polyak and Hayashi (1936), Rogalski (1946), Solnitsky and Harman (1946), and Walker and Weaver (1940).

afferent (Marburg, 1942), and all are myelinated (Bruesch and Arey, 1942), so that there is no opportunity for any "blurring" of the neurophysiological image en route through the optic nerves and tracts. Almost exactly two-thirds of the fibers from each retina (from the nasal moiety) decussate through the chiasma (as do *all* fibers in non-mammals) into the contralateral optic tract, while the remaining (temporal) fibers pass through the ipsilateral tract (Rogalski, 1946).

It was early established by Minkowski that about 80 per cent of all optic tract fibers terminate in the lateral geniculate nucleus in the ventral part of the thalamus, just rostral to the mid-brain. The remainder by-pass the geniculate and travel in the superior brachium of the corpora quadrigemina to the superior colliculus, the pre-tectal region, and perhaps elsewhere also (Marburg, 1942); but any remaining uncertainties here do not concern us, since only the fibers to the geniculate can contribute to visual sensation and perception.

The lateral geniculate receives fibers from the optic tract and from nowhere else. It sends fibers to the primary visual cortex and to nowhere else. It is thus a simple relay station between retina and cortex. The geniculate is complex, but *in Man* it is secondarily simplified as compared with other mammals—even other primates. In it there are six laminae of gray matter (ganglion-cell bodies) separated by white matter consisting of incoming and outgoing fibers which are finding their way to or from the proper cell-bodies. There are *no* intercalary neurons (wholly within the geniculate) in primates, serving to interconnect gray laminae. No incoming human optic-tract fiber gives stimulation to more than one ganglion cell, although even in the rhesus monkey there is on the contrary a "multiplication of paths" which is five- or six-fold (Glees and Clark, 1941). Nor does any primate geniculate cell receive from more than one tract fiber, though such "reciprocal overlap" characterizes some other mammals in which sensitivity to light is of greater importance than spatial discrimination. There are no more ganglion cells in a *human* lateral geniculate nucleus than there are in a *human* retina (Balado and Franke, 1937). Clearly, as concerns the topographic projection of *human* retinal points upon cortical points, the synaptic bed in the geniculate has no significance whatever, for it offers no opportunities for funneling or short-circuiting or any sort of switchboard effects. Each synapsing combination of a retinogeniculate fiber and a geniculocortical fiber might as well be miles away from every other, and indeed might as well be a single continuous fiber from retina to cortex.

A local destruction of the primate retina leads to atrophy of some geniculate ganglion cells in a very few days; for, the latter are deprived of all excitation, and under such circumstances any nerve cell dies in a

week. Such "trans-synaptic" degeneration is practically unique for the lateral geniculate, simply *because* just about nowhere else in the central nervous system does any cell-body receive stimulation from only one, easily-eliminated, fiber. The smallest lesion which one can produce experimentally in, say, the left temporal retina leads to atrophy in three *dots*, all in one line, in the ipsilateral (left) geniculate—one dot in each of three gray-matter laminae. These latter being numbered, from ventrally upwards, one says that the dots are in layers 2, 3, and 5 (Clark and Penman, 1934). The laminae of the geniculate being doubled up, knee-fashion (giving the organ its name), such lines of dots from different retinal lesions would all point to an imaginary "center" beneath the organ; so, one speaks of the atrophies as occurring along one "radius" of the lateral geniculate. Now, if in the nasal part of the *right* retina, a binocularly exactly-correspondent punctate lesion should be made, three more dots of atrophy would appear in the left geniculate, in layers 1, 4, and 6, in the same "radial" line with the atrophic spots in layers 2, 3, and 5. One may be sure that if just *one* ganglion cell in each retina (with the two of them "correspondent") could be killed there would be just two lateral geniculate ganglion cells that would die: these would be on the same side of the brain, in the same radius of the nucleus, and one would be in lamina 2 *or* 3 *or* 5, the other in lamina 1 *or* 4 *or* 6.[3]

If one marks the "macular" region of the retina, and also the remainder (periphery), off into imaginary quadrants, it is found by means of the degeneration technique that each quadrant (and actually, of course, every point in every quadrant) is sharply localized in its representation in the lateral geniculate. The "macular" portion of the latter forms a wedge located superiorly and caudally and comprising rather more than half of the whole organ. The superior peripheral quadrants are localized rostro-medially and the inferior quadrants rostro-laterally, with the residual monocular crescent farthest ventrally. The bi-triple lamination is crispest "macularly" and the laminae are coalesced at their edges, in the farther "peripherally"-representative regions of the geniculate (Clark, 1940).

The outgoing axons from the geniculate ganglion cells form the geniculocortical or geniculocalcarine tract, comprising the greater part of the "optic radiation" to the occipital lobe. They all terminate, at sharply specific loci, in Layer IV of the cortex in Brodmann's Area 17, the striate area (named from the "Gennari stripe" of white matter). Each fiber connected to the ipsilateral retina ends upon a ganglion cell in IV, and

3. While the ipsilateral and contralateral layers do not literally alternate, they do pair off in a way, and in his revised nomenclature Clark (see 1947) lumps the large-celled layers 1 and 2 together as the "a" layers and calls the small-celled layers 3 and 4, and 5 and 6, "b" and "c" respectively.

the correspondent, contralateral fiber ends adjacently (Henschen, 1923, 1926; Kleist, 1934; Rogalski, 1946, but *cf.* von Bonin, 1939).

Area 17 is largely tucked down out of sight, in the walls of the calcarine fissure on the medial side of the occipital lobe, but the relatively enormous "macular" portion of it spills out onto the surface, covers the whole posterior end of the lobe, and even presents upon the lateral surface. The area has been called "banjo-shaped," the head being macular and the stem peripheral. Area 17 comprises no less than 10 per cent of the *entire* cerebral cortex, and contains no less than 38 per cent of all of the ganglion cells in the cortex (Krieg, 1942)—so important, to man, is vision *and* the provision for minute visual-spatial localization.

The smallest lesion that one can produce in Area 17 on one side of the head leads to "dot" atrophies, in one radius through the ipsilateral lateral geniculate (see Polyak, 1933; Clark, 1941b). Such work, and that of Talbot and Marshall (1941), has abundantly confirmed the picture first drawn clearly by Gordon Holmes from studies of individuals with traumatic cortical lesions and correspondingly-localized scotomata in their visual fields: Every topographic locus in the retina is projected to a very particular point in Area 17, with the superior retinal macular and peripheral quadrants occupying the superior half of Area 17, etc. *Area 17 is thus a strict isomorph, a veritable anatomic map, of the retina itself.* Of course *one* Area 17 represents only one half of one retina, and the half of the other retina that views the same half of the visual field.

Clearly, now, if "retinal local sign" is native as to spatiality, it is silly to continue to call it retinal—it is *cortical*, for the arousal of a particular cortical ganglion cell is all that can be immediately accomplished by a ray of light striking a particular retinal receptor, if the latter is a cone having a midget bipolar and a midget ganglion cell and optic-nerve-tract fiber all to itself (see Polyak, 1941). That arousal is the cortical sign of the relation of the responsible light-ray to the eyeball. If now we have our attention upon monocular visual localization (as we do, here), it is equally clear that the cortical sign is not local but *directional*. "Locality" is place, and place is compounded of direction and distance—but an Area-17 cell can tell us nothing of the *distance* of the stimulus from the eye: it informs only of direction with reference to the intrinsic retinal map in which it forms one "point," and hence gives direction within a visual space which is the segment of real space imaged at the moment on the retina *regardless of the attitude of the eyeball in the orbit*. The external material neurophysiologically imaged upon Area 17 is, then, sensory material in a space-field that travels with the eye, and

is "centered" upon the eye—an *oculocentric field*. The direction of any spatial point relative to the direction of the spatial point fixated (or any other—the fixation-point being only a particularly convenient fiduciary for merely didactic purposes) is an *oculocentric direction* whose *cortical sign* is the excitation of a particular Area-17 ganglion cell.

Now, these last statements must in a sense be qualified—but *not* in a way which weakens in the slightest the case for considering oculocentric directions to be given (natively) by this beautiful mechanism which could so obviously base their nativeness. Clark (1941a) established that when even a single upcoming geniculocalcarine fiber is active the Area-17 cell excited *spreads* that excitation in all directions around itself, to neighboring ganglion cells which, excited less and less as they are more distant from "zero," nevertheless may be as much as 5 millimeters away. There are many times as many Area-17 ganglion cells as there are *retinal* ganglion cells. When the primate retina is pretty generally activated, by a complex image-pattern, the result is that in each cortical ganglion cell there is a summed excitation due to the "reciprocal overlap" provided for by the mechanism Clark found. A great many ganglion cells, therefore, are activated when only two *adjacent* foveal cones are stimulated (if we hypothesize such stimulation). Marshall and Talbot (1942) have shown how a comparable system (in the cat) operates neurophysiologically to place the *peak* of excitation (determining oculocentric direction) in any one of many cortical cells *between* the two representing "zero" for each of two adjacent retinal ganglion cells (or cones).

This accounts for the fact that we can directionalize two stimuli relative to each other, oculocentrically, when the subtense of their separation at the eye is a small fraction of the center-to-center separation of adjacent foveal cones. The latter distance is perhaps as small as 25″ arc: but the threshold found in a vernier visual acuity test on a good subject may be as small as 2″, and stero-acuity thresholds (which are mere expressions of liminal total vernier-displacements in opposite directions on the *two* retinas—see Walls, 1943) are of the same order of magnitude.

And, right here, we can already see all the evidence needed to show that oculocentric directions *must* be "inborn." It is conspicuous that no-one has ever been able to propose a *learning* of oculocentric direction in which the "teacher" was anything but *eye-movement*. This was what Lotze, and Helmholtz, and Wundt, and Boring—every empiricist since Berkeley in the field of our problem—had to fall back on.[4] Now,

4. To preserve empiricism and yet dodge eye-movement (though what he thought

it is manifest that under such a supposition, space could not possibly be chopped any finer than the precision of eye-movement would account for. Yet, the vernier threshold is a matter of a few seconds whereas the steadiness of the eye is subject to a fast servo flutter, the "physiological nystagmus," through an angular amplitude measured in *minutes* (see Adler and Fliegelmann, 1934). In binocular vision, to mention this for a moment, the phenomenon of fixation disparity ("retinal slip"), measured also in minutes, is an expression of the size of an "area of Panum," which can be thought of as an adaptive provision against the lack of precision with which the settings of the eye-muscles can be held or repeated. The horizontal radius of an area of Panum is a "± tolerance" allowed the eye-muscles, because the precision of oculocentric directionalization is almost *too* good, so good that it has to be counteracted. Until this tolerance is "used up," *directionalization is not affected*, for diplopia does not replace haplopia until the oculocentric directions of the left- and right-eyed aspects of the object are discernibly different.[5]

Now, of course, it may be objected that Area 17 does not "see" *anything*. Surrounding the primary visuo-sensory, striate, Area 17 on all sides is the secondary visual Area 18, and beyond this in turn lies the visual-association cortex, Area 19. None of these is a "visual center" in the archaic phrenological sense of an end-station, into which sensory messages come and stop. The epoch of behaviorism taught us, if nothing else, to think of every "center" as being on a road to somewhere else. The receiving cells in Area 17 register the optical image as a pattern of excitation within an anatomical image of the retina, but they alone cannot *do* anything about it. For the purposes of *cognition*, and any *action* upon the basis of the visual percept, the pattern must next be transferred out into Area 19. The "image" *here* —if anyone cares—is "right-side-up;" for it has lately been shown that sheets of subcortical fibers connect the lower parts of 17 to the upper parts of 19, and vice versa (Crosby and Henderson, 1948; Henderson, 1949). The ghost of René Descartes must be pleased with this!

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he was avoiding was the repugnant concept of "projection"). Norris (1934) had to develop a preposterous hypothesis which essentially proposed eidola of sorts flowing from the retina to the object!

5. Another importance of the Panum-area phenomenon, not generally understood, is that it enables the prompt perception of an object as solid, and the perception of its plastic shape, even if the object is totally unfamiliar and in the absence of all other cues. The theoretical horopter is a surface. The real horopter, because of the Panum phenomenon, is a solid—it has thickness, within which an object can lie and be seen solid, with every point on it single simultaneously, without need of exploration by eye-movements. Lacking the Panum phenomenon, we could not see even a fixation-point singly unless our eye muscles could hold the eyes steady within two seconds of arc.

Area 19 is adjacent to association-areas relating to other sensory modalities. While consciousness "resides" perhaps everywhere in the cortex, or nowhere and rather in the diencephalon (Penfield, 1937), if we want to speak of where visual percepts are constructed, it is in 19. The raw sensory data, placed by the retina in 17 like the pins on a sales-manager's map, have no *meaning* until 19 receives them and integrates them with other sense-data, "memory traces," etc., to evolve a *perception* of a visual *thing* which has significance for the individual in the light of its context and his past experience. Extensive damage to 19, as is well known, can leave an individual able to see normally but unable to recognize an object unless he also hears it or handles it. It is commonly said of such individuals that they can safely thread their way across "Broadway at 42nd" without having the least idea *what* they are neatly avoiding. A point *not* made by the neuro-anatomical writers is that such a patient, made to rely upon Area 17 alone, still retains his egocentric visual localization, and this remains perfectly coördinated with his tactual-kinaesthetic localization, *although he has been made incapable of employing, by association, for the act of visual localization, anything he ever learned* (and in the broadest sense of that word "learned").

It will be recalled from the preceding paper that versions of the "law of direction" based upon the dioptrics of the eyeball had to give way before the Priestley pinhole-and-pin-shadow experiment, and the directionalization of the Purkinje vessel-shadows, which by-pass the optical system entirely. Versions of the law based upon aim of the axes of the visual cells—"perpendicular to the retina"—had to give way before the directionalization of phosphenes, which by-pass the rods and cones themselves.[6]

But they gave way to "local signs" which were considered *retinal* by their inventor—Lotze—in 1852, and are still taught as retinal. Their localness, as we have noted, should never have been considered anything more than a "direction-ness." Their "retinality," even, would have to give way before any direct experimental *proof* that the whole retina can be by-passed.

Now brain-surgeons, not knowing any better than to be mechanistic nativists about the matter, have expected that if they should give local, mild, electrical stimulation to the visual cortex of a conscious patient undergoing an operation, the patient would enjoy a visual sensation—

6. In the elicitation of electrical, pressure, or other phosphenes by direct "inadequate" (non-photic) stimulation of the retina, the visual cells are not involved. Such stimuli do not break down photochemical substances. It is the nerve cells (bipolars and/or ganglion cells) which serve as the "receptors" here.

perhaps even a visual perception—and would surely be able to localize any such "apparent visual stimulus." A few such experiments have indeed been made, and *with* the expected results. Foerster (1931) obtained reports of little stationary lights or stars when he stimulated in Area 17. Area 18 yielded flames, stars, rings, etc. Area 19 (where "percepts" are built!) gave these, and complex figures, and even little people and animals. These sensations and percepts were of course seen in definite directions. Frantz and Vogel (1946) also described flashes and fireballs from irritations of Area 17, and colored percepts from 18 and 19. Penfield and Boldrey (1937), with perhaps the smallest effective stimuli of any investigators, obtained a report of a small "light" from Area 19, and simultaneously the patient's eyes automatically turned to fixate in the direction in which the light was seen (see also the summary of such work in Duke-Elder, 1949, p. 3695).

I do not hesitate to say that "points of light," in definite directions from the self, could surely also be elicited by direct stimulation of Area 17 in any blind individual whose visual cortex is intact.[7] The experiments cited are enough to show that without the retina's being involved at all, we can see, and we can directionalize what we see. The directional signs that we normally obtain from retinal stimulation are, then, actually cortical. And, they are not "signs," but the directions themselves, as immediately "attached" to cells as ever Hering thought they were.

If these oculocentric directions are given in Area 17, then they must be "given" in the nativist's sense of the word. There is no way in which Area 17 could be educated from elsewhere. Layer IV receives *only* from the lateral geniculate, and the only other messages that come into Area 17 are inhibitory ones to motor cells located there (*v.i.*). Perhaps a desperate ultra-modern empiricist will want to say that even when Foerster's patient saw stars when Area 17 was poked, their *directions* were tacked on after the stars had been transferred to 19, where the results of past "learning" could be brought to bear. I would remind him of the cases with great lesions in 19, who comprehend nothing that they see, but nevertheless do see and do localize, as if Area 17 must be "visually conscious" in its own right. I am willing enough, though, to plod along with him to Area 19. Here, certainly, direction is "perceived" as Penfield and Boldrey have shown. Is the nativeness of direction "seen from" Area 19 to be also denied? It may be, by mere dogmatic assertion. But the assertion must be a whisper

7. Currently, one even reads of proposals to give a sort of vision to the blind by cortical stimulation, through the calvarium, with electronic devices analogous to "electric eye" systems.

when we find, as we do, that if we try to follow the route of visual messages *from* either Area 17 or Area 19, the messages all wend their way down motor pathways and end up as orders to the eye-muscles, to turn the eyes into the very direction in space from which the photic stimulation is coming. We shall consider shortly, then, the relation of eye-movements to the direction of the real and perceptual objects.

We do not need to have an answer to the possibly foolish question of what region of the cortex it is that "sees" the object. Our problem is whether the object has to be seen just "in *that* direction" when it is represented "just *there*" in the neurophysiological image in the retina. Patently, if each ganglion cell in Layer IV of Area 17 "gives" a unique oculocentric direction, then when 19 looks over the fence to see what is where in 17, 19 has to obey the rules. And 17 is built to work with an *inverted* retinal image. Polyak (1941, p. 439) has pointed out that ". . . the biologically more important upper retinal, or lower visual field quadrants. . . . have a relatively larger cortical representation." To assert that the inverted retinal image is not essential for normal visual egocentric directionalization, because we learn this localization and could as easily learn it were the image rotated 180° or 90° or 67.3°, is to ignore (or is to fail to understand) the inborn provisions for seeing better those kinds of things which will normally be imaged upon particular retinal regions.[8]

A further expression of inbuilt local differences in Area 17, correlated with local differences in the perceptual field, is the asymmetry in evaluation of real-spatial extents imaged on the temporal *vs.* nasal halves of the retina and recorded in layer IV. The asymmetry expresses itself in Kundt's Law (of halving) and in the Hering-Hillebrand deviations from the theoretical horopter (see Duke-Elder, 1946, p. 1041). Since all individuals alike find the asymmetry oriented the same with respect to nose and temple, this further demonstrates native isomorphism between Area 17, the retina, and the perceptual visual

8. Even in fishes, which have no visual cortex, the directions in the oculocentric field are so rigidly "fixed" in the optic tectum that if the eyeball is rotated 180° on its axis and sewn in place, the fish responds as if it were seeing upside down. Only one fish out of all the thousands of species enjoys this—the batensoda, which lives upside down and likes it! (see Walls, 1942, p. 523). In salamanders, the developing optic-nerve fibers *themselves* determine where they shall connect within the brain, and thus determine the local signs of retinal points: if an eyeball is grafted into a larval head upside-down, it makes connections and becomes functional, but the animal remains disoriented even for years—a situation curable at any time by rotating the eyeball 180° on its axis (Stone, 1948). The external spatial connotation of the excitation of a visual cell, its opticus fiber, and the latter's predetermined terminus in the brain, are already established when the eye is still an embryonic optic cup (Stone, 1950). An exactly analogous situation obtains in respect of the genesis of cutaneous local signs—in amphibians at least (Miner and Sperry, 1950).

field including the latter's orientation—its up, its down, and its left and right radii.

If we approach Area 17 carrying an empiricistic notion that visual localization is based upon the integration of eye-movements into a primarily haptic spatiality, we must expect to find this area anatomically circular and histologically homogeneous, capable—as Wundt imagined the visual center—of making *any* connections between incoming sensory fibers and outgoing motor ones, on the principle of a telephone exchange. How horrid, then, to find Area 17 banjo-shaped and with visual spatiality built into it in a manner as precise, as pre-determined, and as "mustn't touch" as it is in a wirephoto or television circuit!

SENSATION-EFFECTION ISOMORPHISM

The most ancient category of eye-muscle activities is that of the "compensatory" eye movements set off automatically, reflexly, by the actions of the muscles of the neck and other postural motor systems, and by stimulations of the equilibratory apparatus in the membranous labyrinth of the ear. The spinotectal and bulbotectal tracts, the medial longitudinal fasciculi, and connections with the cerebellum, all mediating communication between the proprioceptors, the labyrinth, etc., and the eye-muscle control-centers in the optic tectum (optic lobes, = superior colliculi), are correspondingly ancient tracts of the central nervous system. It is not generally realized that the oculorotatory muscles were evolved not for the purpose of moving the eye with respect to external space and objects, but for the purpose of keeping the eye still while the head and body moved around *it*. The object of this "gyroscopic stabilization" of the ancient fish eyeball was to keep the material in the visual field stationary on the retina for as much of the time as possible, so that objects would not be seen as moving when they were not, and would be seen as moving when actually they were (Walls, 1942, pp. 300-305).

These essentially proprioceptive reflexes were (and still are, in Man) "in the interests of vision," but their operation does not depend upon vision either in the sense of visual sensation or perception, or in the sense of the employment of the retina as the receptor for an unconscious response. The development and maintenance of these compensatory eye-movements in a young animal will occur normally if the animal is raised in the dark, or if its lids are sealed shut, or even if it has failed to form any optic nerves (Sperry, 1946).

Historically, the next category of eye-movements to appear were "fixative" and "following" movements of the eyes (and, of course, of the whole head and even the body) for the purpose of keeping a moving

object "in sight." These movements, again, were and are of purely reflex character, but they necessarily involved the retina as the receiving end of the reflex arc. The classical experimental device for their elicitation is the rotating vertically-striped cylinder, in response to which the eyes make repeated following movements, properly enough called "optokinetic" or "optomotor" (but *mis*called "nystagmus," for their periodicity is in no way an abnormality, but a procedural artefact).

In the lower vertebrates these optomotor reflexes were necessarily mediated by way of the optic lobes on the roof of the mid-brain, these being the "highest" centers (indeed the only ones) in the visual system. The reflexes have not been discarded by the mammals, and in the latter the homologues of the optic lobes, the superior colliculi, are anatomical maps of the retinas (to which a minority of the optic-nerve fibers "project"), and at the same time are consoles from which harmonies are played upon the various parts of the nuclei of the third, fourth, and sixth nerves. But in the mammals the development of systems of eye-muscle control from the cortex (*via* the colliculi, of course) has relegated the direct retina → colliculus → eye-muscles circuit to a position of relative unimportance. The circuit can be given an advantage by strychninization of the colliculus, whereupon the fixative eye-movements become more automatic and pronounced than they are in the normal animal (see Apter, 1946). In Man, however, the "low" circuit through the colliculus has lost all importance.

The advent of cortical eye-movement control had several aspects. With visual "consciousness," in the mammals, installed in their nice new cortex, it was logical that the motor controls should be placed handy to the receptive cortical loci. But although there was as much need as ever for automatic tracking of visual objects (that would not require "thought"), there also came to be need for voluntary eye-movements.[9] Now, voluntary eye-movements were no innovation of the mammals—they occur also in those lower vertebrates which have a fovea. Only if there is a fovea (or at least an area centralis) does the animal need to be able to *aim* the eye at any object in order to see it better (see Walls, 1942). In the mammals, however, there arose for the first time the necessity of being able to operate voluntary eye-movements, demanding visual awareness and the use of the cortex, and also

9. The cortically-operated tracking reflex may still be at work with a *motionless* object, as when one looks at another person's face while shaking the head in the "no" gesture. Here, the optomotor reflex involving the retina and the visual cortex is cooperating with the compensatory reflexes involving the labyrinth and the neck-muscle proprioceptors. Both systems converge at the superior colliculus and the pontine lateral-gaze center, and go on as one to the eye-muscle cranial nerve nuclei

to operate reflex eye-movements by way of the visual cortex, without interference between the two systems. In short, the animal must be able to let a moving object move his eyes to keep the object on the fovea effortlessly, but he must not be at the mercy of this automatism: he must be able to "take his eyes off" such an object and look at anything else he pleases. And, he must of course be able to enjoy "single" perception of a binocular object, the while the maintenance of its singleness is cared for by completely automatic processes that do not require conscious *perception* at all.

It was apparently Holmes (1938) who first spoke of an "occipital oculomotor center" in Man. Ever since it came to be realized that the "fixation," "following," and "fusional" reflexes have the visual cortex as a station on their pathways, the text-books have said *something* about all this. But the statements have generally been pretty vague and "general." All three kinds of movements have been lumped together, as if they were really only one, and as if a single kind of stimulus or a single aspect of the stimulus could initiate them all. A sneaking suspicion that if the visual cortex is involved, visual *perception* must be involved, led to the coining of the unfortunate adjectives "psycho-optic," etc., for these *reflexes*. And, it must be admitted that a suddenly-presented stimulus does not initiate automatic fixation of it, nor does a moving stimulus instigate automatic pursuit, unless—it *seems*—the stimulus is one that "takes our attention."[10]

In the light of the "50 papers" mentioned in the preceding section —particularly, some of the most recent of them—we are now in a position to be somewhat less vague than the current text-books, as regards the operations of the "occipital oculomotor center." We now know that both Area 17 and Area 18 are involved, and with separate functions: and, we know (or can guess with confidence) a good deal about the relations of these centers to the patch of voluntary eye-movement cortex, in the second gyrus of the frontal lobe, known as "Area 8." On the face of things, Area 17 looks like a passive recorder, and may therefore be the "logical" candidate for the mediation of the *maintenance*, by pursuit, of fixation already attained, and the maintenance of the continuous bifixation which we nowadays call motor fusion, or simply fusion. Area 18 would seem more likely to be the center mediating the initial adoption of fixation of a new, initially peripheral, stimulus that "takes the attention"—if this does require any awareness, or even

10. It is still considered unsettled whether there are "psychic" components in accommodation and convergence—*i.e.*, whether conscious awareness or estimation of the distance of the object, given by various "cues," plays a part in bringing the ciliary muscle and the horizontal recti to their settings. Positive evidence is, however, accumulating.

"unconscious inference," of the presence of the stimulus. Let us see what is *known*:

With our attention, as it is here, only upon visual *direction*, let us suppose that the left eye is covered and the right eye is in the primary position in a motionless head. Suddenly a bright "star" stimulus is presented in a place, or in a direction from the eye, such that it is imaged on some cone in the fundus, but not in the center of the fovea—in, say, the superior temporal quadrant of the retina. This particular cone has a midget bipolar cell and a midget ganglion cell to itself, and a single optic-nerve fiber is therefore concerned. This fiber travels to the medial segment of the right lateral geniculate nucleus and ends, in an "ipsilateral" lamina, upon the body of a ganglion cell. The axon from this cell travels to Area 17 and ends there, in Layer IV, upon the body of a "receiving" ganglion cell.

Now in that immediate vicinity, in Area 17, there are the cell-bodies of *motor* cells—"cells of Meynert"—some of which are in Layer IV but most of which lie in Layer VI, deeper in the cortex. These cells will be activated just the same whether only our "receiving" ganglion cell has been excited, or only its opposite number in Layer IV connected with the "corresponding point" in the *other* retina, or both. The Meynert-cell axons, now, travel through the internal sagittal stratum and the internal capsule to the midbrain, in the occipital division of the internal corticotectal tracts (Clark, 1942a, 1942b; Crosby and Henderson, 1948; Henderson, 1949). This fiber-population, then, is an anatomical isomorph of Area 17—and therefore, of the retina. The fibers terminate in the supra-nuclear control-centers for the eye-muscles: in the superior colliculi for the operation of the muscles as regards the vertical movements and vertical components of movements of the eyeball, and in the pontine lateral-gaze center (at the superior end of each vestibular-nucleus complex) for the operation of the horizontal recti particularly.

The image of our star, transferred to these centers, now sets off a ready-made "plan" for the operation of all of the muscles of the right eye[11] in just such a way as to slide the fixating spot in the center of the fovea under the optical image of the stimulus-light. In short, the eye turns to look, with its fovea, in the direction of the light, and the process has been entirely automatic. Awareness of the light and of its direction may have arisen *before* the fovea gets there, or not—it doesn't matter. So goes the operation of our fixation reflex.

This reflex becomes perfected, in the infant, just as soon as the

11. And of the covered left eye also: but we are not concerned here with binocular phenomena.

fovea itself is finished and employable, which is not for some weeks after birth. The appearance may thus be given, that the infant cannot fixate until it has somehow learned visual localization in terms of some more primary system of localization. This need for time for *maturation* of the fovea is indeed exasperating; for it, and nothing else, is what traps the unwary, who may even think it logical that the infant at first sees upside-down, and is learning to perceive otherwise during this period of maturation. With the embryonic development of the human retina not well worked out until relatively recently, the elder nativists were accused of a "foul" whenever they adduced the obvious *inborn* coordination of vision and taction-kinaesthesia in lower animals. But it is *not* irrelevant, to our present problem, that a chick can peck accurately at bright objects with the eggshell still clinging to its tail, or that there is an entire family of birds (the Megapodidae; see Knowlton, 1909, pp. 268-271) in which the young can *fly* as soon as they are hatched, or that a newborn guinea-pig, or foal, or calf, can exhibit perfect visual orientation before the amniotic liquor has dried on its pelt. The relative maturity of *these* infants makes their performances possible—and human infants in a comparable *stage* can do comparable things.*

The anatomy of the fixation reflex pathways makes no sense unless the direction of the stimulus, when it does come into consciousness, is natively given. The pathways are built to work with only an inverted-reverted retinal image, for a part of egocentric localization is given by the *reflex innervations* to the muscles; and *these*, in the nature of things, are not learned or even learnable. The workings of this purely automatic system are such that a fixated point is seen in the egocentric direction in which the eye is aimed. If a fixation-reflex stimulus were to be presented in an objectively "up" location, but were also imaged on the upper part of the retina, the fixation reflex would aim the eye down, away from the point; but the immutable innervation-pattern would directionalize the percept in the direction of aim—*i.e.*, where the point *wasn't*, with respect to the person's real body. This would never do; nor could the person "make everything alright" merely by deciding to *call* up "down," and down "up."

Man has dispensed with every "instinct" and every piece of automatic behavior that he could, and economizes greatly by substituting learning and insight. But he has retained the "psycho-optic" reflexes.

*In Desmonceaux's classic account of a hypermature infant (born at the end of a 13-month pregnancy), the neonate's visual orientation was so complete that it was hard to manage unless its face was covered to keep it from squirming around to look at things. Desmonceaux believed that an infant's visual behavior would be completely adult "at birth, if the physical mechanisms were sufficiently complete" (see Dennis, 1937).

The mechanism that implements them is so obviously one in which native directionalization can and must reside, that it is preposterous to propose that Man should make no use of it, and instead painfully *learn* to see an object as in a certain direction when it is imaged at a particular place on the retina with the eyeball in a particular orbital posture. The *very same spot* in the visual cortex that mediates the perception of the object is in automatic control of that orbital posture, unless we actually *inhibit* its control!

The fixation reflex operates just as well, no matter what orbital posture the eye happens to have when the stimulus is given. Clearly, the visual system maintains a continuous record of the orders being sent to the supra-nuclear control centers, and this is the "base-line" from which the changes in orders, necessary for the automatic fixation, are sent down. This continuous record is *made use of* in Area 19, which is kept informed of the whole situation in 17, contains isomorphs of both the sensory and motor aspects of that situation, and can itself operate fixation reflexes (see Henderson, 1949). It is the use of this record, as one of the two elements in egocentric localization, that we mean when we speak of a "sense of innervation" (Helmholtz), the "will to move the eyes" (Mach), or an "adjustment factor" (von Kries). Area 17 is responsible only for oculocentric direction, and nothing that can happen within 17 can give the localization of the oculocentric field as a whole, and therefore of its contents, within the egocentric space-field.[12] Unless and until we know better, we shall have to suppose that it is in 19 that oculocentric direction and innervation-sense are "put together" to give *egocentric* direction (*v.i.*).

Voluntary eye movements *presume* localization—we could not desire or decide to fixate an object without knowing in advance where it was, and of course the object need not even be in the visual field before the eye-movement is made. The mere fact that voluntary eye-movements occur in Man, as in other foveate vertebrates, is no evidence for the given-ness of visual directions. No matter where we *perceive* an object to be, whether up when it is actually down, or leftward when it is really rightward, its image will be brought into the fovea if we look toward where we think it is. But to make the above information of more general usefulness to the reader interested in more than just the direction

12. We can now understand better how spatial discrimination can be finer than the motor steadiness of fixation. We can make a vernier-acuity setting with an error of a few arc seconds, while the eye is vibrating in the "physiological nystagmus"—and yet, we see the target as perfectly steady in space. Even the servo flutter of the innervation pattern is being "recorded," so that these eye-movements are not permitted to affect the localization of the target or its parts. The full potential precision of oculocentric directionalization is therefore available for the discrimination.

problem, we need a few words about voluntary eye-movement.

The "center" is Area 8, which contains a built-in isomorph of the potential space-field that can be viewed with the eye in the totality of its possible orbital postures. Local electrical stimulation in Area 8 elicits definite, conjugated, directionalized eye-movements. In commonplace vision, Area 8 cannot *initiate* an eye-movement—though it is the center of voluntary movements, it has no "volition" of its own: it takes orders. These orders come to Area 8 from many parts of the cortex, wherever the "idea" or intent of looking in a particular direction may evolve. Conspicuously, Area 19 sends many fibers to Area 8. Any piece of visual material in Area 17 may, when related to other matters in 19 and in the parietal cortex generally, lead to a voluntary fixative, avertive, or other eye-movement. We may, then, think of 19 as giving the order to 8, which executes it by way of the basal ganglia and the supranuclear and nuclear eye-muscle control centers. But, to *permit* the voluntary movement, the fixation and tracking reflexes must be suspended. Area 8 is therefore amply connected with Area 18 by fibers which bring inhibitory messages for 18 to relay into 17 and 19.[13] "Carbon copies" of *all* excitatory and inhibitory messages are of course sent to the perceptual apparatus to be integrated into the innervation-sense factor in localization. The optical image can now shift over the retina as the eye moves, without this causing any apparent movement of the "field" or of any stationary object within it.

EGOCENTRIC AND OCULOCENTRIC DIRECTIONALIZATION

It is time the distinction between oculocentric direction and egocentric direction was made completely clear. When the eye is in the primary position, (the position of physiological rest), whatever is imaged on the fovea is seen "straight ahead." The directions of other objects are to the left, up, etc., in accordance with the locations of their representations in Area 17. Everything that is seen, is seen within an oculocentric field. The visual ego, the "self," is *as if* located at the perspective center of the eyeball, for in its primary position the eye records two objects as aligned with the self if they are on a straight line through the perspective center. The material on a television screen is organized not with reference to the location of the receiver, but with reference to the location of the camera. Area 17 is the screen, but the eye is the camera.

13. Some of the most fascinating cases described in the neurological texts are those of individuals with lesions covering Area 8. Not only are they unable to turn their eyes "at command," but they have no means of inhibiting the fixation reflex. They can "take their eyes off" of a moving object only by closing the eyes or turning the head to remove the object from the visual field, etc.

The oculocentric field is the totality of all oculocentric directions. It has a margin or "frame," anatomically represented by two isomorphs, the ora serrata of the retina and the perimeter of Area 17. The perceptual field and its frame are "there," independent of any *contents* (*i.e.*, things-to-see). Nothing, perhaps, makes this so clear as the fact that if on steady fixation in the primary position an after-image is developed, this after-image "travels with the eye" during any subsequent eye-movements, just as the spot of light cast by a flashlight travels with any turning of the flashlight. The *oculocentric* direction of every part of the after-image is fixed because the directional "sign" of every participating Area-17 cell is permanent.

But, the movement of the eye moves the after-image in an egocentric perceptual space centered upon the body-image, or its head-portion. (The same result, of course, would follow a movement of the head, with the closed eye motionless in the orbit). The after-image is given a new egocentric direction by the eye-movement: and, if the eye should be opened in its secondary position, anything now imaged upon the fovea would have a different egocentric direction from that of the still-visible former stimulus that had been responsible for the foveal portion of the after-image.

In effect, the *frame* of the oculocentric field is swung here and there in the egocentric field as if the eye-muscles were attached to *it*. It is, in fact, very easy to demonstrate that the muscular effort (as represented by the innervations *to* the muscles) is what swings the whole oculocentric field about, and not actual movement of the actual eyeball, nor the tensions in the muscles reported kinaesthetically.[14] If I cover one eye and turn the other eye up and down, successive objects imaged on the fovea are seen in successive egocentric directions although they all have the same oculocentric direction. As the eye moves, no object seems to move, for (which is to say the same thing:) its egocentric direction is constant. If, while the eye moved, an object imaged on the fovea *remained* imaged on the fovea, that object would appear as moving.

14. It is now known that there *are* typical proprioceptive endings in human oculorotatory muscles (Sunderland, 1949; Cooper and Daniel, 1949), and that therefore the "spindles" described so long ago by Siemerling and by Buzzard (1908) were not freaks after all. Moreover, the "grape-like" endings (long known) may also be proprioceptive—the fibers from them have been traced not into sensory ganglia but into the *motor* nuclei of the eye-muscle nerves (Corbin and Harrison, 1942). It is practically certain, however, that their activities never get up into consciousness, nor even so far "up" as the perceptual apparatus in which visual localization is established. Göthlin (1946) found an oscillation of after-images accompanying vestibular nystagmus, and thought this might prove eye-muscle kinaesthesia. But it seems only to confirm the idea that eye-movements initiated from the labyrinth cause visual apparent movements if the (opposite) head-movements that ordinarily accompany them are lacking (see a later footnote, and "rule 5" to which it refers).

even if the field were otherwise empty. Its oculocentric direction would be constant, but its egocentric direction would change continuously with, and "proportional to," the eye-movement. This would not be easy to arrange for experimentally; but one can get the same effect, without apparatus, by first developing a foveal after-image and *then* moving the eye up and down: the "object" is in corresponding motion.

If, however, I develop the foveal after-image, close the eye, or turn out the lights, and *push* the eyeball up and down, the egocentric direction of the "object" does not change. The eye is again moving, but constantly-foveal visual material is not seen as moving. I am stimulating eye-muscle proprioceptors; but *they* are telling nothing to the localizing mechanism. Now, I open the eye and again voluntarily turn it up and down. No object moves, though images are moving over the retina. Keeping the eye open, I *push* it up and down: now, images are moving over the retina, and *everything* "moves."

If I rotate my head into one posture or another with the eye as the center of rotation, and then each time turn my eye voluntarily to fixate always the same object in the room, its egocentric direction is always the same: *voluntary* movement of the eye in the orbit does not change the egocentric direction of a stationary object constantly or repeatedly imaged on the fovea (or on any other constant part of the retina). But I can fixate the object and shake my head gently in the "no" gesture. Again the egocentric direction of the object is constant although *now* the movement of the eye with respect to the orbit is governed by a complex of labyrinthine-compensatory and occipital-optomotor reflexes.

I can "will" my eye to remain in the primary position in the orbit, and turn my head from left to right with the labyrinthine compensatory reflexes thus under attempted inhibition. The flow of visual material across the egocentric field is as smooth as the movement of the head is, and no object appears in motion. This, despite the fact that another person can readily note that my eye *is* moving in the orbit in a characteristic optomotor "nystagmus," occipitally-mediated, of which I am quite unaware. If I repeat this movement of the head (with the eyes willed motionless) as a pursuit of an object moved from left to right by an assistant, the optomotor movements of the eye relative to the orbit do not now occur; but the flow of the background is no smoother than it was in the former case, when the motion of the retinal image of each object, relative to the retina, was made highly compound through the combination of steady rightward head-movement with right-left-right-left eye-movement.

From all of these considerations, we can extract four simple principles that govern egocentric directionalization in the commonplace monocular vision[15] of a normal individual whose head is in its "primary" position:

1. When the eye is in the position of physiological rest, egocentric direction immediately coincides with oculocentric direction—the egocentric direction of any seen point *is* now its oculocentric direction.
2. A muscle-produced eye-movement, whether voluntary and/or of retinally-mediated reflex character, gives a correspondingly new egocentric direction to the whole oculocentric field as a unit, hence gives a continuously new egocentric direction to any object that preserves its oculocentric direction during the eye-movement, i.e., a moving object the retinal image of which does not move on the retina. Two different stationary objects which occupy the same position in the oculocentric field respectively before the eye-movement and after it are given, by the eye-movement, correspondingly different egocentric directions.
3. An object the image of which moves over the retina is perceived as moving in accordance with its changing oculocentric direction, unless the image-movement is being entirely caused by voluntary or retinally-reflex muscle-produced eye-movement, whereupon the object is perceived as motionless in egocentric space.
4. A passive eye-movement does not alter the egocentric direction of the oculocentric field, hence gives no new egocentric direction to any object that preserves its oculocentric direction during the movement. Such an object, although necessarily actually in motion, appears motionless since its egocentric direction remains constant in keeping with the intended muscular

15. *Binocular* directionalization is greatly complicated by the fact that in a normal individual the "frames" of the two oculocentric fields are perpetually in congruence. This can be laid to the *partial* decussation of the optic nerves, resulting in congruent biretinal projection of each pair of corresponding "points" to one "point" in Area 17 (although the biological *value* of this is that it automatizes the cooperation of the "psycho-optic" reflexes of the two eyes—binocular non-mammals surely see "singly" with totally-decussated optic nerves; see Walls, 1942, pp. 323-6). Ordinarily it does no harm, since the *contents* of the oculocentric fields are near-enough identical. If however one fovea could regard a house on the left, while the other regarded a tree on the right, the tree and house would be seen superimposed. They would "have to" be seen in a single egocentric direction. Apparently the perceptual apparatus would have to "make up its mind" whether to see them both to the left or both to the right. A bird, lizard, or fish is in no such predicament! I have my own answer for the "dilemma" pointed out here; but, I am struggling *not* to discuss binocular vision in this particular paper.

determination of eye posture. All actually stationary objects are however perceived as moving during the passive eye-movement, in accordance with "3."

To these rules we may add another when *head* movement is allowed into consideration (although we must draw the line arbitrarily, else the rules will accumulate with every involvement of additional proprioceptive mechanisms):

5. An eye-movement, whether muscle-produced (and voluntary or reflex), *or* passive, which exactly compensates for a head-movement, does not alter the body-image-centered direction of the oculocentric field, or of any objectively stationary contents of that field. But this is because the head movement also exactly compensates for the eye-movement. Labyrinthine reflex eye-movements, normally compensatory for head-movements, give correspondingly new egocentric directions to the whole oculocentric field if the head-movement is lacking—the result then being (as, *ee.gg.*, in caloric nystagmus and in vertigo) an apparent movement of objective space and its contents.

The one and only reason why these simple (yet amazing) rules exist is that the whole "record" of the pattern of all innervation to the oculorotatory muscles, as well as the whole proprioceptive inflow from the neck muscles, etc., is continuously available to the "localizing department" of the perceptual apparatus.[16] The "innervation-sense," or rather the innervation-pattern, which normally determines the aim of the eyeball from the orbit, is ingeniously made use of also as a factor in perception—to swing the oculocentric field about in the potential, Kantian egocentric space. An important result is that the changes in oculocentric direction of truly motionless objects during muscular eye-movement are exactly "cancelled" so that—in accordance with "rule 3"—their egocentric directions do *not* change:

If I fixate a motionless point with the eye in, say, the primary position, and then turn the eye 10° leftward, the oculocentric-direction factor would now cause me to see the point as moving to lie 10° to the right of the straight-ahead direction, for it is imaged 10° to the left of the fovea and could be said to be imaged 10 cortical degrees cortically rightward from the cortical fovea (in Area 17). But the "unconscious

16. There is one important exception. In the "swimming" of the visual field in caloric nystagmus and vertigo (see Cogan, 1948, pp. 128-130) we have a demonstration (see "rule 5") that the innervation to the eye-muscles initiated from labyrinthine stimulation is *not* entered in "the record." This negligence of Nature is excusable, for she never intended that labyrinth-operated eye-movements should ever occur except in exact compensation for *other* movements, the kinaesthetic responses to which *are* a part of "the record."

innervation-sense" is also reporting that the eye has been turned 10° leftward, and this information exactly countermands the report from Area 17 that the point has moved 10° rightward. So, the point remains perceptually where it really is—straight ahead. I make no doubt whatever that a person in whom both lateral geniculate nuclei had been neatly extirpated, and who was now given continuous electrical stimulation at one point in Area 17, would see a "star" in an egocentric direction that would change if he moved his eyes voluntarily, or if they moved in an optomotor reflex mediated by way of the superior colliculi, etc.

The nativeness of *oculocentric* directions with respect to the body image has surely been abundantly established here—and was, indeed, conceded by Berkeley. Disregarding eye movement entirely, oculocentric "up" (for example), as a specific self-originating direction, is native whether it is named or not. As soon as we become aware, ontogenetically, of the direction of gravity, we can begin to *call* oculocentric up "up," if we can speak the word. From our "rule 1" alone we already find a positive answer to the question: "Is the inverted retinal image essential for normal visual localization?" But the "learning" of visual directions claimed by the empiricists, upon close scrutiny, turns out to pertain (and pertains *only*) to the innervation-sense factor in egocentric localization, with moving gaze. *Is* the employment of this factor possibly *learned;* or is it, too, native?[17] Of course an infant with its head "straight" and its eyes averted never does reach straight ahead for a laterally-placed object imaged on the fovea(s); but here, as ever, we encounter that maturation period during which the infant might have been "trying" to do just such a thing, but was not yet old enough to reach out and grasp anything anyway.

It would be presumptive evidence of "learnedness" if it can be shown that the mode of employment of the innervation-record is *alterable*, affecting egocentric localization—provided those effects are something more than mere *translatory* shifts of the oculocentric field without rotary re-orientation of it within egocentric space. That is, if it is found that the innervation-sense can take on a new "zero," so that any *foveal* object is seen (say) 10° rightward when the eye is in the position of physiological rest, then the oculocentric field has only been "slid sidewise." Seeing an object farther rightward, or farther upward, etc., than it actually is, is merely a "constant error"—we do make such errors (very small ones!) anyway. The altered egocentric field would

17. We would not even have to raise this question, if only an occasional individual, born without eye-muscles, were available for study. In such a person, the entire nerve supply of the muscles and every higher neuron concerned with their operation would automatically be lacking also.

still be a perfect isomorph of the original egocentric field.

No, it will have to be shown, rather, that some altered mode of employment of the innervation-record can interchange up and down, or right and left. What kinds of alteration *can* be shown to be possible?

The visual localizing system can be tricked, and may then *seem* to alter or even to break down. We have noted the results of passive movements of the eyeball induced by finger pressure, and the results of unconscious, uncompensated, "labyrinthine" eye-movements. Here however there is no new employment or mal-employment of any of the normal factors in localization. The falsification of visual direction is due merely to an abnormality in the situation, quite outside the province of the localizing system. So also with the conspicuous phenomenon of "false projection" in the attempted, intended, and presumed turning of an eye toward the side of a paralyzed eye-muscle. Here, past-pointing crisply demonstrates that visual and haptic localizations of the same object have been thrown out of agreement. The visual localization may be branded fallacious—but this is for the reason that the *way* of localizing has *not* been altered. The muscle is not being properly actuated by its innervation and the eyeball is therefore disobedient—but the localization mechanism cannot be expected to "know" this.

If the variable factor in egocentric visual localization were eye-muscle kinaesthesia (as it was once thought to be!), then it might be supposed that in such abnormal situations as those above, localizations would never be falsified. But if egocentric localization depended upon eye-muscle kinaesthesis, the only people who would be happy would be the neo-empiricists ("Aha! A system which, everyone knows, one would have to *learn* to use!"). They, like the rest of us, would be immediately miserable when they tried to *see*, for the system could not work: I should then have to see any continuously foveal object as being in motion to the right if I turned my eye to the right, no matter whether the object was really moving, or was really motionless and merely being kept fixated during a leftward head-rotation. Making the head movement capable of suspending the eye-muscle kinaesthesis would not make the system workable either, for there would then be no reporting of the orbital posture of the eye, and the oculocentric field would be frozen in a false egocentric direction "straight ahead" from the face. Nor could the neck- and eye-kinaesthesias be made compensatory, for if then the head were turned leftward with the eyes motionless in the orbits, the visual field would move leftward, for there would be no opposing eye-kinaesthesia to keep it "still."

The only situations I have learned of that suggest that the mode of employment of the innervation-pattern factor might be altered

ontogenetically, relate to binocular vision, which must therefore be allowed to elbow its way into this discussion again—bringing with it its most baffling manifestation, anomalous correspondence. This is just as well, for it so happens that the questions of the nature and physiological basis of even *normal* correspondence are quite pertinent to the problem of the ontogenesis of visual orientation:

The normal inter-retinal correspondency that makes haplopia ("binocular single vision") possible is in the peculiar position of not *having* to be innate and of yet not *having* to be learned. Since the fixation reflex occurs for each eye, it is binocular; and, *being* a reflex, it is of course a "given" thing. So, correspondency could not fail to develop (if it "had to" *develop*), and could not fail to accord with a rigid schema predetermined by simple morphological geometry. If the fixing points in the two foveas are correspondent (and no one would deny the innateness of this), the paired-off correspondency of all other points can "come out only one way," so that if it were not native it would be just as predictable as if it were. Manifestly, however, a point in one retina cannot "correspond" (for haplopia) to anything in the other retina unless its oculocentric directional value is different from that of any other point in its own retina—unless, in short, it is unique, and unique to begin with. Herein, then, lies a further argument for oculocentric directions to turn out to be just what they are whether they are claimed to be native or not—and, with no invocation of eye-movement as an educatory device. Consider also the owl, who has no eye-movement and yet has foveas, and would sooner regard an object with both of them at once than otherwise.

When we start to try to understand anomalous correspondence, we should have it in mind that the basis of normal correspondence is *not* the microscopically-fine adjacency, in layer IV of the cortex, of the representations of each pair of retinal corresponding points. (If that were true, Panum's areas would be microscopic too.) That adjacency, and the whole anatomical congruence of IV*n* and IV*t**, facilitates (but does not insure) the perceptual congruence of the two oculocentric fields and their frames. We have noted that in the human lateral geniculate there is not the least opportunity for any blending of ipsilateral and contralateral sensory data. There may be no more opportunity for such blending in Area 17. The Gennari stripe, there, is positively not

*The "*n*" and "*t*" here are not to be interpreted as designating anatomical sub-*layers* of Layer IV, but the populations of ganglion cells there (stellates? star pyramids?) which are the most immediate receivers of excitation stemming from (respectively) the *nasal* hemiretina of the contralateral eye and the *temporal* hemiretina of the ipsilateral eye. Kleist's theory, of a subdivision of Layer IV into an ipsilateral "IVa" and a contralateral "IVc", separated by the Gennari stripe, is in the discard.

the "binocular fusion center" that Kleist thought it to be: It is predominantly an intracortical conducting fiber system (Clark, 1941a), and the few large cell-bodies in it are those of motor elements belonging to the Meynert-cell system—the upper-motor-neuron portion of the efferent arm of the fixation-reflex arc.

The adjacency of members of each Area-17 pair of corresponding-retinal-point representations is not, as I see it, necessary for the kind of physiological correspondency that leads to perceptual correspondency or haplopia. Rather, its function is to insure the motor unification of the fixation reflexes of the two eyes into a precise binocular fixation reflex and "motor fusion" reflex. The histological rigidity of the situation in Area 17 should not blind us to the fact that actual binocular vision is *as if* a little "slippage" of Layer IV*n* with respect to IV*t* could occur. If this were not so, there would be no Panum's-area phenomenon, and there could be no fixation disparity without diplopia. There would be no tolerances upon eye-muscle settings, and vision itself would be intolerable.

One has to suppose that all such slippage actually takes place "in" (*i.e.*, through operations in) Area 19—between the transferred data from 17-IV*n* and the transferred data from 17-IV*t*. What was once called "retinal slip" is, then, probably a slippage-before-"fusion" of the Area-19 isomorphs of the left- and right-eyed images. Considering the general properties and capabilities of Area 19, this is not implausible. This, now, brings us to *anomalous* correspondence.

Anomalous correspondence is no mere matter of dilated Panum areas. The "angle of anomaly," which with caution may be thought of as an angle of falsity of "projection" via the deviating eye, may be as much at 15° (Duke-Elder, 1949). Anomalous correspondence is only one of several possible "escapes" from diplopia available to the squinter; and, moreover, only a minority of anomalous correspondencies are of the "harmonious" kind (with the angle of anomaly equalling the angle of squint). Furthermore, only 5-10 per cent of the harmonious anomalous corresponders see continuously and comfortably with both foveas simultaneously.[18] Relatively uncommon as squinters of just *this* type are, they are the only kind we need to consider here.

The simple facts, now, are that such a squinter has one eye that deviates (either in or out) by a fairly constant angle; he sees in its true direction any object imaged upon the fovea of his "straight" eye; he sees this same object in its true direction from the peripheral-retinal spot on which it is imaged in the deviating eye—so, he sees the object singly:

18. Personal communication from Dr. Meredith W. Morgan, Jr.

simultaneously, any object imaged upon the fovea of the deviating eye is seen in a *different* egocentric direction, which is *its* true direction, and is the direction in which the deviating eye is aimed.

Discussions of this phenomenon treat it as though necessarily its basis must be an undoing of what I have called (above) the normal perpetual perceptual congruence of the two oculocentric fields, which would exist for anyone.[19] It is probable that the patients we are considering *do* have the frames of their two oculocentric fields out of congruence, and locked together in a new relationship such that one is offset "laterally" from the other to an extent that compensates for the deviation of one eye and places a peripheral "substitute macula" in that eye in true correspondence with the fovea of the "straight" eye. The individual's egocentric localizations would then be given by employing the innervation-record exactly as a normal person does.

But, the superficially motor nature of the deviation *per se*, together with the fact that the deviating eye has a relatedly altered posture as its position of physiological rest, suggests just as well that the entire basis of the phenomenon might lie in the presence or development of separate innervation-records for the two eyes and their separate employment for egocentric directionalizing of the separate oculocentric fields.

This implies that the oculocentric frames *are* separate, *i.e.*, not inevitably locked together. What is it that makes it *appear* that they are normally locked in congruence? Is it anything more than the fact that the normal individual is not a squinter, and has the "innervation-sense" as a joint and unitary one for the two eyes? All the evidence is in favor of the view that in a normal individual the locking is real. But if our completely adjusted squinter has been able to undo the lock, we do not have to suppose that his oculocentric frames are then locked again in an offset relationship. We need only suppose that they stay unlocked, and that the patient uses separate innervation-records—with that for the deviating eye having an adjusted "zero." The fixation and fusion reflexes would have to be surrendered by Area 17 to Area 18 (which sends down the necessary motor fibers) so that the angle of squint can be maintained in order to maintain the new correspondency, etc., etc.

All this sounds complicated. Too complicated. The "necessities"

19. Even for the few persons (see Ayer, 1929; Barrett, 1921; Spiller, 1927) who can move their two eyes independently. None of these, nor the harmonious anomalous corresponder with simultaneous foveal perceptions, approaches the performance of lower vertebrates which—as conspicuously exemplified by the African chamaleons—can look forward or sideward with one eye while looking sideward or backward with the other, attending to the unlike contents of both oculocentric fields without evidencing the least confusion.

pile up, the moment one tries to desert the idea that the basis of the phenomenon is anything more than a whopping slippage in Area 19, giving a new correspondency of exactly the same character as the old. True, the anomalous correspondency has been accused of being only "quasi-" (see Duke-Elder, 1949, p. 3854), for it is not characterized by perfect stability, nor by stereoscopic perception with high stereo acuity. It is unreasonable however to expect such things from such a horse-and-pony combination as a genuine fovea and a patch of peripheral retina: and in fact *stereoscopic* perception of haplopic objects has never been required by any reasonable definition of correspondence, but only the *haplopic* perception, the *singleness*. There is no evidence that "true" correspondence in the normal is anything more than the same community-of-directionalization that the anomalous corresponder is exhibiting. For haplopia, such community is necessary and sufficient.

It seems to me that an insuperable obstacle to any theory of anomalous correspondence couched in terms of an altered-innervation-record-employment is the monocular diplopia so likely to be exhibited by the deviating eye if the deviation is corrected surgically. When this diplopia exists, it can only mean that a slipped IV*n*-IV*t* relationship in Area 19 is persisting while an unslipped one is being established or re-established. This is no more mysterious than the double print one would get on photographic paper if one let the negative shift on the paper half-way through the exposure. But to account for it in motor terms instead of in sensory-cortical terms, one would have to think that the innervation-record could connote two different postures of the eyeball simultaneously. This is unthinkable, for me at least.

The fact that anomalous correspondence takes time to *develop*, and the fact that the angle of anomaly can change with a change in the angle of deviation in the same individual, suggests at first thought that the oculocentric frames in all of us are completely unlocked, with egocentric directions given entirely by a joint binocular innervation-record which the anomalous corresponder has succeeded in cutting into two separate monocular innervation-records. But the frames could as well be locked at all times—with, however, an "off-set" *possible* and with its extent slowly changeable, much as two magnets will constantly cling to each other although one of them *can* be moved over the surface of the other.

In any event, there is nothing about anomalous correspondence to suggest that the oculocentric fields can ever be made to make any shifts, with respect to each other, that are not purely *translatory*: they always preserve identical orientations, like the cars on a Ferris wheel, or like

the images seen through a Wollaston prism when it is rotated. So long as Donders' and Listing's laws remain in force, it will remain unimaginable that any new mode of employment of the innervation-record could be acquired by an individual, of such character as to *rotate* the native oculocentric cones of directions and make visual "up" become visual "down" and vice versa.

The third and final paper of this series will present an analysis of past experimentation on the problem of visual direction, and will appear in the April issue of the AMERICAN JOURNAL OF OPTOMETRY.

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A REPORT ON TEN CASES FITTED WITH THE FEINBLOOM SELF CENTERING CORNEAL CONTACT LENS*

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Since its conception in 1888, when Fick produced a device for the correction of kerataconus, the contact lens has enjoyed a variegated history. During this span of 62 years it has grown, attended by the usual problems, broadened its scope, and finally reached maturity. It has now attained an advanced stature with the introduction of the Feinbloom self-centering corneal contact lens.

This new lens presented by Feinbloom at the 1949 meeting of the American Academy of Optometry represents a tremendous advancement in contact lens fitting. It has increased wearing time, given the patient greater comfort, it is truly invisible, and has reduced fitting time to as little as one visit in the simpler cases. Fitting is far more accurate, due to the fact that the correct lens is completely self-centering from the moment of its insertion. The constant use of forceps to eliminate lag and shifting is now practically a thing of the past. Added to this, is the use of a new buffer solution, called Metsol, a methyl cellulose compound developed and introduced by John C. Neill of Philadelphia, at our meeting last year. Together, the combination of this solution and the self-centering lens, have made this past year a more gratifying one in the contact lens field.

For the past 20 years, conversations with prospective contact lens patients were always on a very cautious basis—purposely so to avoid arousing any false hopes. The patient was left with the understanding that he would have to demonstrate that he could wear the lenses for four hours with comfort before the lenses could be designed. That while this was all we could hope for, the possibility that he might be able to wear the lens for longer periods was possible. Only time could tell. No attempt was made to urge any patient in their use, much less attempt to induce others to substitute contact lenses for spectacles. Today this has changed. We now look forward with confidence to fitting the self-centering corneal lens.

This report on 10 cases fitted with the new Feinbloom lens was

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written after each of the 10 patients was contacted by telephone. The case reports are as follows:

1. M. G. Female, age 22, clerical worker. Miss G. had been a patient for two years prior to using contact lenses. She had always entertained thoughts of having them, but parental disuasion caused her to put off getting them. Her last correction was O. U. —4.50 D. Sph. ⌒ 0.50 D. cyl. x 90, which gave her a visual acuity of 20/20. In addition, she manifested 1Δ of left hyperphoria. This was never corrected, either optically or by visual training since the patient never offered any history or complaint that might point to the hyperphoria producing any asthenopia. Her only complaint was that she disliked having to wear glasses.

She was fitted with the "B" Feinbloom lens after three visits. The first visit consisted of choosing the proper lens and checking with fluorescein. The second, wearing the lenses for two hours to test for reaction. The third was the four hour test. At the end of this period it was found that it took an hour and fifteen minutes for the "haze" to disappear.

As is usual with all the author's cases, the prescription ordered ground into the corneal section was undercorrected in minus power in the initial lenses. When the patient returned for her progress check at the end of one month the subjective test revealed the need for an additional amount of minus sphere. The new correction gave her a visual acuity of 20/20 O. U. At her next re-examination three weeks later, she reported being able to wear the lenses for six hours and of "not feeling that the lenses were in her eyes." She says she now sees better with her contact lenses than with her spectacles. Two months later, she reported being able to wear them for ten hours. She now has had her lenses for 10 months.

During a telephone conversation she had the greatest praise for the lenses, reporting she could wear them for twelve to thirteen hours daily. She does not use the suction cup to remove the lenses, but simply has the lenses drop out by widening the palpebral aperture. This case offered no difficulty in either the fitting process or at any other time.

2. R. B. Male, age 21, employed in a paper mill. The patient was wearing O. U. —3.75 D. Sph. ⌒ —0.25 D. cyl. x 180, which gave him a visual acuity of 20/20—. He wanted contact lenses for two reasons. First, to use while driving his motorcycle, and second to keep small particles of dust and lint from entering his eyes while at the mill. He was fitted with a Feinbloom "B" lens at the first visit and went on to wear the trial lenses for the two and four hour tests. Haze disappeared at the end of the four hour test in twenty-five minutes. At his first

monthly progress report he told of the haze beginning after six hours. The patient reported that he had worn the lenses eleven hours the day previous, the first eight hours with complete ease and no haze.

In response to the call made to him, he was high in his praises of the lenses. He claimed he had worn them as long as fourteen hours, and one day even forgot to remove them at bedtime. The next day when he removed the lenses, his eyes felt, he said, "a bit uncomfortable." This patient has used his lenses for 10 months.

3. S. C., age 22, an ex-GI, now studying Russian and Diesel engines. He was given spectacles many years ago, which he refused to wear because they made his eyes "feel funny." His uncorrected visual acuity was O. D. 20/200— O. S. 20/180. Subjectively, he accepted O. D. —2.75 D. Sph. ⊃ 0.25 D. cyl. x 180, O. S. —2.50 D. Sph. ⊃ —0.75 D. cyl. x 180. Visual acuity O. U. 20/20. 3Δ exophoria at distance, 8Δ exophoria at near, 2Δ left hyperphoria at distance and no vertical imbalance at near. He was fitted with the Feinbloom "C" lens on the first visit. At his progress report a month after delivery of the lenses he told of complete comfort with "no feeling that the lenses were in his eyes." The patient could wear them from five to six hours, but had not tried to wear them longer.

Later the author's telephone call brought out the patient's ability to now wear his lenses twelve to fourteen hours. He was invited to come into the office and try a new solution,[1] purported to aid him in wearing his lenses for longer periods. His lenses were then treated with a 12.8% zephiran chloride solution. He was given a .1% solution of zephiran in which to keep his lenses immersed upon removal. He was asked to call back and report his results. The patient has now had his lenses for eight months.

4. G. M. Male, age 29, radio and TV announcer. This patient was first seen two years ago. He had broken his glasses and come in for refraction. He had aniseikonia since 1940 and had had three lens changes, none of which gave him as much comfort as the original prescription. He was wearing—without satisfaction—a GI issue, O. D. —3.25 D. Sph. ⊃ —0.25 D. cyl. x 90, O. S. —3.00 D. Sph. ⊃ —0.75 D. cyl. x 90. The new correction given him was only slightly different from this prescription, with the exception that each lens was made on a different base curve in the attempt to overcome his aniseikonic correction. His uncorrected visual acuity was O. U. 20/500. At his progress report a month later, he said these new glasses were no better than any of his others.

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[1]D. Scott and A. L. Sirkis. Increasing the Wearing Time of Contact Lenses. Optometric Weekly. August 31 issue, 1950.

He was next seen in the Spring of 1950, and asked to be fitted with contact lenses. He had received a 13 weeks' contract as a TV announcer, and didn't want to wear spectacles before the cameras. Inspection disclosed a chronic conjunctivitis, which he had had for as long as he could remember.

He was fitted with a Feinbloom "C" lens, wearing them for only thirty to forty-five minutes in the office. This was enough to satisfy him, since his TV show was to be for fifteen minutes. The day he received his contact lenses, he wore them for two hours and twenty-five minutes, and reported haze disappearing an hour and forty-five minutes after removal. This extra wearing time permitted him to insert his lenses one hour before telecast time. He reported complete satisfaction with the performance of the contact lenses after his first appearance on TV. He could watch the image on the television receiver offstage for his cues, and this pleased him.

The telephone call evoked the following conversation. "I am a self-confessed poor subject for any type of lens; for handiness on TV they (contact lenses) are ideal. They serve their purpose well, and are perfectly fine for the use wanted. I wear the correction only when it is extremely necessary. I haven't given the contact lenses a fair test but I can wear them for two and a half hours in spite of the conjunctivitis problem." It is now eight months since this patient first received his contact lenses.

5. J. L. Female, age 30, stenographer. Miss L. has been a patient of the author for 10 years. She wears O. D. —5.25 D. Sph. ⌒ —1.00 D. cyl. x 180. O. S. —6.00 D. Sph. ⌒ —1.00 D. cyl. x 180. Visual acuity of O. U. 20/20. Phorias and ductions normal. She asked to be fitted with contact lenses in April, 1950. Attempts to put a lens in her eye were fruitless, since she "tightened up." In addition, she had a small palpebral opening and tight lids. The procedure was reversed and she was first taught to insert the lenses herself. After that, all lenses were inserted by the patient. Ophthalmometer reading was recorded as O. D. 47.50 x 180. 49.00 x 90. O. S. 48.25 x 180. 48.75 x 90.

The nasal sclera of each eye fell away sharply into a "football type." A Feinbloom "A" lens was tried, but this proved too big, both for the palpebral opening, and the fit on the sclera. The "A-2" lens, while giving almost no fluorscein picture, seemed to fit best of all. This she wore through one hour, two and four hour tests with no onset of haze. The trial lenses were worn as they were with the nasal section standing away from the sclera about 2 to 2.5 mm. This gave rise to a slapping sound, but the patient was reassured that this sound would not be present with her own lenses, since those would be adjusted when

they were received. On delivery of the patient's prepared lenses, they were adjusted with the forceps closing the nasal gap. Six adjustments were made on the lenses, one each day during the first week. The patient was then instructed to wear the lenses for two weeks, and return for further examination. This she did, and reported being able to wear the lenses for a period of one and a half hours only, ending with injection of the sclera. She was refitted with a new pair of lenses made up in the "A" type Feinbloom lens. These too, necessitated adjustment with the forceps and again ability to wear for one and a half hours only. She was then sent to New York City to see Dr. William Feinbloom, who fitted her with a "1+A" lens with the same result in wearing time.

She was again refitted with "½ + alpha" lens. After one week, she reported being able to wear these new lenses for an average of four hours, and added the comment that the Metsol "caked up" on her eyelids. It was therefore suggested that she go back to the 1% sodium bicarbonate solution.

Her case is still pending final disposal. This is the only unsuccessful case yet encountered.

6. E. S. Male, age 33, printing press operator. Patient had entertained thoughts of getting contact lenses for many years. His visual acuity was 20/50. His appearance was that of near albinism. His ophthalmic correction was O. D. —5.00 D. Sph. ⌒ —0.75 D. cyl. x 180. O. S. —5.25 D. Sph. ⌒ 0.50 D. cyl. x 180. In addition, he had a left Emersonian (hyper) eye of 4 mm.

He was fitted with Feinbloom "B" lenses, and went through his fitting period with only minor injection. At his progress re-examination he told of having worn the lenses overnight and had "worked up to nine hours before haze," though the average was seven hours. His visual acuity with the contact lenses was found to be 20/20—1 O. U.

When he was called by telephone he told of his wearing his lenses daily from 7 A. M. to 5 P. M., while at work, and then putting them in after dinner for the rest of the evening. It might be interesting to add that he returned a few months after receiving his contact lenses for examination for regular spectacles. His prescription was increased to O. D. —6.50 D. Sph. ⌒ —1.00 D. cyl. x 180. O. S. —7.00 D. Sph. ⌒ —0.75 D. cyl. x 180. This new correction gave him a visual acuity of 20/30, but which he contended made things blurry, objects were vague, and that they did not compare in any way with his contact lenses which he has been wearing for 11 months.

7. J. K. Female, age 15, high school student. The patient wanted contact lenses because she "disliked glasses" and "mother disliked them even more." She was wearing —3.00 D. Sph. O. U. which gave her a

visual acuity of 20/25 in the right eye and 20/30 in the left, but had no discomfort with these glasses which she had received 18 months ago. All findings negative. She was fitted with Feinbloom "B" lenses, which gave a perfect fluorescein pattern and went through her four hour test easily. Haze was gone 15 minutes after removal of lenses. Her lenses were reground after one month. Her next progress re-examination found her able to wear her lenses for eight hours with haze disappearing after one hour; no pain; no irritation, and satisfaction with contact lenses. The patient is interested in the theater and during her appearance in a play at school, was very thrilled with her ability to see clearly onstage for the first time. Her previous appearances behind the footlights had always been without glasses. She has been wearing her contact lenses for seven months.

This patient's father reported that his daughter had used her contact lenses for as long as 11 hours without discomfort. He also reported a marked personality change in her.

8. J. H. Male, age 25, optometrist. Visual acuity corrected with his spectacles to 20/20. Patient was wearing O. D. —3.00 D. Sph. O. S. —3.25 D. Sph. ⌒ —0.25 D. cyl. x 5. Fitted with Feinbloom "B" lenses which were reground after one month to give a visual acuity of 20/20. His lenses were also treated with zephiran chloride and he keeps his lenses overnight in the .1% solution.

At first, the patient was able to wear his lenses for five and one-half hours and after zephiran treatment, for six and one-half hours. Onset of haze is from three and one-half to four hours, at this writing. He now has had his lenses four months.

9. W. G. Male, age 20, clerk in grocery store. Referred by an optometrist who diagnosed keratoconus. The patient claimed that vision had dropped during the past year. He had been to an ophthalmologist about a year ago who attempted to fit contact lenses and then discouraged their use. Visual acuity with spectacle correction O. D. 20/80. O. S. 20/1000. The patient was wearing a correction O. D. —4.50 D. Sph. ⌒ +5.50 D. cyl. x 160. O. S. —3.50 D. Sph. ⌒ +4.50 D. cyl. x 15. While he was fitted in only three visits, it might be added that extra time was spent at each visit in order to avoid the necessity of extra sessions, since he came from a distance of 60 miles.

The day the subjective refraction was done with the contact lenses in place, the patient recorded a visual acuity of O. D. 20/20—, O. S. 20/30—. He was able to wear his lenses for four hours and forty-five minutes during this test. At his progress re-examination, a month after receiving his lenses, he expressed disappointment at being able to wear his lenses for only five and one-half hours. He had hoped to be able to

wear them for much longer periods of time. His visual acuity now was recorded as O. D. 20/20+. O. S. 20/25+. It is four months since this patient received his lenses. He can now wear his lenses for 13 hours daily.

10. F. T. Male, age 40, barber. This patient had just learned to swim and looked forward to contact lenses affording greater comfort in the water. He was wearing O. D. —10.00 D. Sph. ⌒ —2.50 D. cyl. x 90. O. S. —10.00 D. Sph. ⌒ —2.50 D. cyl. axis 110, in lenticular form. These gave him a visual acuity of O. D. 20/30, O. S. 20/40. It took two visits to show that the Feinbloom "B" lens was the correct one. His next visit, which was to have been the two hour test, was increased to four, when he returned after two hours showing no signs of injection and apparently enjoying this new adventure.

At the progress examination, the additional minus was ordered reground. The lenses then gave him a visual acuity of 20/20— in each eye. During the telephone conversation, his comments were, "the lenses are wonderful, they give me no trouble at all. I have worn them for eight hours and the haze disappears in forty to fifty minutes." He also added that he had used them for paper hanging in his home and that here they had proved very satisfactory. Using the lenses in the barber shop reduced the fear of hair particles entering his eyes. He has had his lenses two months.

SUMMARY AND CONCLUSION

Case reports of 10 patients fitted with Feinbloom self-centering corneal lenses are submitted. These are distributed as follows:

Three female and seven male case reports are submitted. The number of office visits required for fitting were one to three for nine cases, and eight visits in one case. The patients reported upon have been wearing their contact lenses from two to eleven months. One case can use the lenses for two hours. One case for four hours. One case for six hours and seven cases wear them from eight to fourteen hours. The Alpha Feinbloom lens was used on one case. The "B" Feinbloom lens in seven cases and the "C" Feinbloom lens in two cases.

These 10 cases, taken as a group, present a much different aspect of contact lens fitting than heretofore experienced by the author, who has fitted many types of contact lenses in the past. With these new lenses there were fewer deprecating remarks from patients and the lenses seemed to come up to patients' expectations.

All of the present group of patients have continued to use their lenses which in itself is exceptional.

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STATE OPTOMETRY IN BRITAIN*

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This paper is presented to the American Academy of Optometry in view of the proposal to set up a scheme of state optometry in the United States of America.

It is felt that an account of the history and methods of such schemes in Britain may be of help to American optometrists in combating the inception of state optometry, or of avoiding some of the pitfalls in the event of the proposal being passed by the Congress.

Prior to 1912 there was no British state assistance for any sick person, except those who came under the scope of the Poor Law. These paupers were a comparatively small class who were absolutely destitute and for whom "infirmaries" were provided, where medical attention of a not very high order was given.

No self-respecting person would accept this attention or the "parish relief" which was its companion for keeping together body and soul in the destitute. The careful and thrifty worker became a member of a friendly society or sick club, which enabled him to have the services of a medical man and a few shillings a week during illness, but most workers were in a bad way when sickness came along.

To meet the problem of providing for all working people who fell on hard times during sickness, the British statesman, Mr. David Lloyd George, Minister of Health in 1912, drew up a scheme of National Insurance for sickness and unemployment under which, for something less than a shilling a week, those insured became entitled to visit their physicians as often as they considered necessary. They also received medicine without further charge and about 15/- per week when incapacitated by illness. That was the medical side of the scheme and it received about half the contributions for National Health and Unemployment Insurance.

As is usual in such a great social change as was involved in bringing millions of people into a scheme under which they were forced to pay weekly contributions, and under which medical men who had been the strongest of individualists were forced to accept some of the

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discipline of bureaucracy, there was much opposition.

Mr. Lloyd George calmed the Friendly Societies by using their machinery for the administration of benefits, and utilized the services of a doctor, now Lord Addison, to overcome the scruples of the medical men. Many, if not most, of the latter were bitterly opposed to the scheme, but it is important to note that their opposition was overcome at that time and has been on other occasions since, as has that of all such groups opposed to Government medical schemes. The secret is that professional men have a high standard of living to keep up, and have much to lose if they are prevented from maintaining a good income, as they would be if prevented by politicians from taking part in what is almost a government monopoly. Inevitably, they toe the line because if they do not, their less heroic professional brethren will toe it in sufficient numbers to enable the scheme to work. Once it is working, those outside have a thin time and are forced into it.

When the first British National Health scheme had been working for a few years, most Friendly Societies began to accumulate funds. Each five years, the government auditor made a survey, and any surplus had to be distributed to members. It was felt better to make the distribution in additional benefits than in cash, and such benefits as ophthalmic, dental, maternity, convalescent home and surgical appliance came into being by 1922.

In that year, the main optometric associations in Britain—the British Optical Association and the Institute of Ophthalmic Opticians (representing diploma holders of the Worshipful Company of Spectacle Makers of the City of London)—went into consultation with the Friendly Societies and evolved a scheme of ophthalmic benefit. Under this scheme, an insured person requiring optometric attention obtained a letter from his Friendly Society for presentation to his optometrist. The optometrist examined his eyes, and if spectacles were necessary, sent an estimate to the society. This estimate included a fee of 5/- for examination (the first time such a fee became common in Britain) and the cost of the spectacles was 15 per cent below the optometrist's usual charges. In most cases, the Friendly Society accepted the estimate and made a grant of 10/- or more, which might be paid to the member or to the optometrist.

There were disadvantages in this scheme, among them being (1) only the individual actually paying the contributions received benefit. His or her dependents, who were often more in need of it, did not receive any. (2) Optometrists did not publish lists of charges, and it was sometimes doubtful if the charge for spectacles was actually 15 per cent below the usual. (3) Owing to the great differences in the

sizes of the Friendly Societies and their administration costs, surplus funds varied greatly, as did the amounts allotted to the various kinds of benefit. It was therefore possible for one person to obtain no ophthalmic benefit, for another to obtain 10/- and another 30/-, when all were paying the same contributions.

The disadvantage of uncertain charges was eliminated by the setting up of a government sponsored "Ophthalmic Benefit Joint Committee," which formulated charges for lenses and a limited range of frames. Thus in 1938, a reinforced cellulose frame with curved lenses was supplied by the British optometrist to state insured persons at an average charge of about 25/- plus 5/- examination fee (approximately $7.00 at that time). If this charge seems low, it must be remembered that in districts where the average weekly income was above £5 ($25.00 then), most people would be outside the National Health Insurance, and higher charges would apply.

In addition to the purely refractive cases, those people who needed ophthalmic medical attention were referred by the optometrist to an ophthalmic medical practitioner. He gave any necessary medical treatment and also, if it were necessary, a prescription for spectacles which was sent to the referring optometrist for dispensing.

Such was the condition of affairs in state optometry in Britain until 1948, except that the examination fee had risen to 7/6 and the cost of spectacles to about 37/6 a pair (total, approximately $10.00 in 1948).

Then, with the great revolution in social services brought about by the British Labor Government in July, 1948, the National Health Insurance scheme was completely swept away and the National Health Service took its place.

It is the declared intention of the government that private medical practice, including optometry, shall be abolished entirely by the National Health Service. To this end, every person in the community who is gainfully employed, whatever his or her income, must contribute to the cost of social services, contributions averaging something like 8/- per week. For this, every person in the community, man, woman or child, is entitled to visit the physician as often as is thought necessary by the patient, and all essential medicines and appliances (including spectacles) are supplied without further charge. In addition to the medical services, unemployment benefit, pensions and other benefits are covered by the weekly contributions. Even if none of the benefits is taken by a man who chooses to pay privately, he must still pay the contributions.

So far as optometry is concerned, if a physician certifies that in his opinion a patient should have his eyes examined, the patient may have this done and any necessary spectacles supplied without charge provided the frame is of nickel and zylonite. If the frame is of reinforced cellulose with pad-bridge, and curved lenses are supplied for reading, a charge of about 10/- is made. Curved lenses are supplied for distance vision without charge. Fused and solid bifocals are also supplied without charge when essential.

For a refractive examination and prescription, the optometrist receives a fee of 14/. The prescription is sent to a local office of the National Health Service, where it is recorded and sent to the patient. With the prescription is sent a letter, telling the patient that it may be presented to any optometrist or dispensary optician for dispensing, and it is a regrettable fact that most British optometrists will dispense prescriptions of other practitioners, even when practicing in the same town. A fee of 24/- is paid for dispensing one pair of lenses and 34/- for two pairs. Nothing extra is paid for dispensing a frame. All materials are paid for by the N. H. S. at cost, plus 5 per cent to cover breakages. A standard prescription price list has been laid down by the organizations representing prescription laboratories.

In order to keep what was hoped would be a substantial amount of private practice, the optometrists' representatives managed to persuade the government negotiators to restrict the frames supplied under the N. H. S. to a limited range, from which in actual practice only about four styles are chosen by the great majority of people. All "fashion" styles, such as rimless, library and engraved gold-filled, must be paid for in full by the patient, the N. H. S. paying only the examination fee. It was hoped by the optometrists' organizations that this regulation would persuade many people to go outside the N. H. S., with its necessity for a medical certificate, and obtain eye care by paying privately. This has not proved to be the case. Fully 95 per cent of people requiring eye care since July, 1948, in Britain have obtained it through N. H. S. The restricted range of frame styles has had a monotonizing effect on the appearance of spectacle wearers, and the efforts of those in the optical industry who would introduce new and better styles has been almost nullified.

In the beginning of the N. H. S., reinforced cellulose frames were supplied without charge, unless they had pad-bridges, when the charge was 1/6, or curl-sides, when it was 6/-. As lenses were free, this meant that the tastes of the great majority of potential wearers of spectacles in Britain could be satisfied at a charge of only a few shillings at most.

Contributions being enforced and benefits relatively easily obtained, millions of people took the opportunity of getting some value for their money by visiting the physician and then the optometrist. Such a great demand could not be met by the restricted manufacturing capacity of the optical industry, which had barely the facilities for meeting the far smaller demand of pre-N. H. S. days, and had not been warned by the Government that much greater supplies would be necessary.

Consequently, after a few weeks, when the small stocks of lenses and frames had gone, delays in making spectacles began to grow. Very soon, the delay for the simplest of prescriptions was three months, then six, and then up to a year. The great demand could have been kept within reasonable proportions from the start by making a charge of 5/- or 10/- for all except the barest optical necessities. People had been used to this under the National Health Insurance scheme and were amazed to learn that almost all spectacles were free under the National Health Service.

The long delays discouraged many people from making application for ophthalmic treatment and with the introduction of a charge of about 5/- for reinforced cellulose frames, demand for eye care has now dwindled to such an extent that ordinary prescriptions are filled within two weeks. Bifocal prescriptions still take six months in most cases. This lower demand is taking the prosperity out of optometry. Twenty cases per week at an average of £2 per case in examination and dispensing fees does not leave a great margin, when all overhead expenses and income tax at 9/- in the pound have been paid.

It has been mentioned earlier that the declared aim of the government is to abolish private practice in optometry. They hope to build up the Hospital Eye Service to such an extent that the day will come when all applicants for state eye care can be told that they must go to a hospital to get it. The present scheme under which optometrists attend to state patients in their private consulting rooms is called the Supplementary Ophthalmic Service—supplementary to the Hospital Eye Service, although it does by far the greater amount of work. A clause in the National Health Service Act gives the Minister power to declare the end of the Supplementary Ophthalmic Service in any area when he is satisfied that the permanent service is able to cope with the requirements in that area.

That is the threat which is hanging over the heads of British optometrists and which will probably hang over the optometrists of any country which adopts a state optometric service. In the opinion of the writer, it is not necessary to provide free optometry, except to chil-

dren of poor people and the needy aged. It is far better for people to pay for eye care in a straightforward manner, as they do for other necessities of life. At most, a grant of half the cost should be provided if help is needed, and optometrists should do their best to keep ophthalmic benefit schemes within the above limits.

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ABSTRACTS

VOLUNTARY HEALTH INSURANCE ON THE NATIONAL SCENE: THE PROGRAM OF THE INSURANCE COMPANIES. M. D. Miller. American Journal of Public Health. 40. 1125-1128. Sept., 1950.

The author of the paper is an actuary with an insurance company. The development of the health insurance program of the companies writing group insurance is described in some detail. Optometrists may find the following paragraph of some interest:

"Considerable interest has been evidenced in forms of medical expense insurance other than hospital expense and surgical operations coverage, and here we come into less proven areas. When we analyze medical services and related expenses we find a great variety of circumstances. At one extreme are instances where medical expenses are unpredictable and may be, and often are, burdensome, as where hospitalization or surgery is required. At the other extreme are expenses for services such as visits to an ophthalmologist for the prescription of eyeglasses, or the one or two doctor's visits required in many minor illnesses. Expenses for such services, the need for which is often entirely predictable, are well within one's ability to pay for out of current income. Including them in an insurance plan serves only to increase their cost because, aside from any question of possible abuse, the cost of administration must be added to the cost of benefits. The cost of handling small payments at frequent intervals is relatively high, so that perhaps as much as $4 is required for the payment of $3 in benefits. Such considerations lead some to feel that expenses for predictable services and minor illnesses are not a proper subject for any insurance arrangement."

RICHARD FENTON.

THE DYNA-SCOPE AS AN AID IN OFFICE AND HOME VISUAL TRAINING*

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Since first presenting the Dyna-Scope to the orthoptic section of the American Academy of Optometry during the 1949 meeting in Cleveland, Ohio, a further report and some personal observations regarding the techniques behind the Dyna-Scope will be of interest to the orthoptist.

The Dyna-Scope was originally invented to enable patients to view and superimpose stereoscopically projected pictures. Its use makes it possible to view any stereogram or stereoscopic set of pictures, since its action, produced by the turning of two articulated mirrors, contains the equivalent of twenty-five degree prisms, base-out, and fifteen degree prisms base-in.

It was soon discovered that viewing any object in space through the Dyna-Scope also afforded an opportunity to break and recover fusion, the repetition of which increased the latitude of this function to a marked degree. Fusion reserves were developed after which patients reported increased comfort, and tests showed improved visual efficiency.

To assure and control both peripheral and foveal fusion during visual training it was necessary to design a suspension control chart which provides monocular points of identification within the binocularly fused target. With this chart, suspension of either eye becomes a conscious act and the patient sees for himself what he is to achieve in order to see normally.

The Dyna-Scope with red and green filters, plus the chart, make up the entire equipment used for home exercises. However, the Dyna-Scope lends itself to simple base-in or out exercises as the case may require without any further equipment. The patient can use any specific object located within the field of vision as a target.

The patient may not detect suspension during exercises, therefore, cases exhibiting suspension should train with the benefits of the controls offered by the chart.

The writer will now review some of the reasons for using the Dyna-Scope.

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Normal binocular vision is a complex integration of sensory and motor reactions. Those which are of greatest importance to this orthoptic discussion are:

The area of attraction to fusion. This is the area lying between the reversion to fusion points. The area surrounding a point of fixation within which the two visual fields are attracted to each other, i.e., where diplopically perceived images become a binocularly seen single image. This area is normally found to be within a span of about 8 to 10 degrees prism base-out, and 4 to 5 degrees prism base-in, or a total area of 12 to 15 degrees within which fusion is retained and held.

Attraction to fusion is the phenomenon of instant attraction and super-imposition of two retinal images within the borders of the sensitive area of attraction to fusion.

Intensity of fusion is the speed and accuracy with which separate images are superimposed and fused.

Peripheral fusion is an overlapping and fusing of the peripherally perceived disparate retinal images *while foveal fusion remains suspended.*

Foveal fusion consists of the conscious superimposition of the image of the point of fixation on the fovea, which sets off a train of mental processes such as a blending of the images into one, stereopsis, distance judgment, comprehension, kinesthetic responses, etc.

Fusion consists of the total result of the superimposition of the retinal images in the peripheries and either one or both foveae of the eyes, which, in terms of disparity sets off a train of mental processes known as binocular vision. A few of these factors are, the blending of the images into one, stereopsis, distance judgment, comprehension, kinesthetic responses, etc. "Fusion is the satisfaction of a mental desire for a single image." (Atkinson.)

Foveal suspension. *Normal:* The physiological suspension of foveal vision during eye movements to avoid diplopia. *Abnormal:* The continued and sometimes conscious suspension of foveal vision during a poor or sluggish response to fusion within the area of attraction. This requires more time for the visual axes to find the area of attraction within which the point of fixation is located. It is logical to assume that foveal suspension can be lifted only after peripheral and foveal superimposition is attained.

Since the point of fixation in space is rarely stationary, and the eyes move from point to point slowly or rapidly as the occasion demands, it follows, that *abnormal* foveal suspension must necessarily be continued over prolonged periods of time. The completed fusion act lags behind over one or many changes in visual fixations before both visual axes find the area of attraction to fusion.

It is this acquired skill of prolonged foveal suspension which is the defense mechanism with which the brain protects itself against blur or diplopia due to incomplete fusion. Barring pathology this type of foveal suspension is most apt to respond to visual training.

From the preceding definitions it should be possible to construct a working model of the area in binocular vision which responds to training with the Dyna-Scope.

DYNASCOPY

This consists of the training of the cortical centers of the brain to see an object binocularly while the visual axes are manipulated to cross in front of, or behind, the object viewed, while the brain maintains visual fusion through control of the motor and proprioceptive nerve impulses which innervate and direct the ocular muscles involved in seeing.

THE DYNA-SCOPE

This is an instrument composed of articulated mirrors or prisms which is interposed between the eyes and the point of fixation by means of which the patient can, at will, manually, converge or diverge the visual axes within the limits of the area of attraction to fusion for the purpose of strengthening the attraction and intensity to fusion through exercise and the elimination of foveal suspension through conscious, repeated exposure of the faulty suspension area to the brain.

Localization. It is of primary importance to bear in mind that in order to see binocularly the eyes must first find the object to be viewed (localization). Both visual axes must be placed within the area of attraction to fusion. This area may be severely constricted in size, or sluggish in its response, *resulting in a prolonged effort of the brain to locate and fuse the two retinal images.* Just as two searchlight beams may overshoot and undershoot their target in the dark sky, so may the visual axes overshoot and undershoot before settling down to the necessary alignment within the area of attraction to fusion. One eye may fix on the object while the non-fixing eye is not yet in line with the attraction to fusion area, or the eyes may have superimposed the images peripherally but not foveally within the attraction to fusion area.

In these cases we may assume that the non-fixing eye suspends foveally until both foveal areas are super-imposed, when the *foveal suspension is lifted and binocular vision begins.* While normally this suspension lasts but the fraction of a second, it is repeated every time fixation is changed from one object to another. Under abnormal conditions *foveal suspension may continue* over several changes of visual fixations. This is particularly true if the attraction to fusion is slower than the

changes in fixation. In these cases the suspension continues until the target is found and superimposed within the area of fusion attraction.

Since the target may be in motion or the eyes change their position faster than the area of fusion attraction will react, foveal suspension in the pursuing eye must necessarily continue until the object viewed is exposed long enough to complete the superimposition of the foveal images within the eventually located area of fusion attraction.

This prolonged abnormal suspension seems to be the defense mechanism of the brain against blurred vision and diplopia.

THE DYNA-SCOPE IN USE

The left eye is covered and the Dyna-Scope is placed before the right eye. The patient is instructed to move the visual field seen through the Dyna-Scope from right to left and return. The patient is to keep it moving. After learning to move the field horizontally, or, by tilting the instrument handle, obliquely, the left eye is uncovered. A stationary and a moving field is seen by the patient. The patient keeps moving the latter horizontally across the stationary field. After having identified the presence of two fields, fusion training begins.

Most patients easily find their area of fusion attraction anywhere within the 25 degrees base-out and 15 degrees base-in range of the Dyna-Scope and learn to increase their attraction to fusion power by increasing the convergence and/or divergence recovery to fusion range *while the brain holds foveal and peripheral fusion.*

Even the slightest increase in these visual functions is reflected in immediate improvement in the patient's visual efficiency. Patients with amblyopia, and strabismus require more practice but the ability to deal with their problem at the source, the area of fusion attraction affords every opportunity for self help with the patient doing it himself, at home.

A comparison of some differences between the Dyna-Scope and presently used orthoptic techniques may be of interest; these are:

(1) Dyna-Scope training is done at infinity or any intermediate distance.

(2) It is stereoscopic, that is, disparate retinal correspondence is present during the exercise, which means real, natural, conditions prevail during treatment periods.

(3) Being a home training instrument, it affords many more training periods than office training. It is invaluable to the patient who must travel long distances, the busy executive, the invalid or to the monocular individual who is being taught to see binocularly in the office

but who reverts to monocular seeing because of the overly long interval between training periods.

(4) Most important as a training feature is that both peripheral and foveal fusion are under observation. Foveal fusion is consciously maintained during exercise. Eyes do not just move around without actually fusing foveally with each fixation. An appeal to mental participation is constantly present.

SUMMARY

(1) The *area* of attraction to fusion is *reviewed.*

(2) The *intensity* of this attraction is outlined.

(3) *Prolonged foveal suspension,* as an acquired skill to prevent blur or diplopia has been briefly summarized to direct the reader's attention to the author's belief that visual training must be directed to these three specific functions.

Exercises must be done under as nearly natural conditions as possible to stimulate that other component of integrated vision skills, the patient's mental participation and awareness of reality.

The Dyna-Scope as an instrument for visual training at home and its special utility for injecting a mental appeal to fusion and the correction of foveal suspension was described.

Attention is called to the important function in binocular vision of the area of fusion attraction.

Intensity of fusion attraction and foveal suspension respond to Dyna-Scope training.

Home training is often the only possible method which brings satisfactory results. The patient's cooperation is usually improved because of the convenience and persistence with which home training may be carried out by means of the suggested techniques.

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VAIL'S SUGGESTIONS ON OPTOMETRIC-OPHTHALMOLOGICAL RELATIONS

After frankly discussing reasons for ophthalmological dissatisfaction with optometry, Dr. Derrick Vail, president of the American Academy of Ophthalmology, made several suggestions at the Illinois Optometric Association annual meeting in February which would if followed, he claimed, bring about a better understanding between the practitioners of both groups.

Among the things proposed by Vail were that optometrists seek legal responsibility for the recognition of ocular pathology, and that they assume this responsibility as expected of all professional men in their clinical practice with the public. In this, Vail was not suggesting

that optometrists diagnose or treat ocular pathology. He was, however, suggesting that more attention be given this subject and optometrists be held legally responsible that their refractive and orthoptic cases be free from ocular pathology. Vail pointed out that the opportunities for more advanced training in this area of optometric work were now open and that it was the duty of the profession itself to avail themselves of these opportunities.

Vail also urged the continuance of optometry's fight against commercialism and cultism and indicated that he saw many evidences that this effort was proving successful.

He further pointed out that full cooperation between optometry and ophthalmology was now possible and should be fought for by both groups.

Vail has been long considered the spearhead of ophthalmological opposition to optometry. On occasions in the past, optometrists generally have felt that he carried his opposition and fight against optometric practice to extreme degrees entirely out of proportion to the questions at hand. In his address before the Illinois Optometric Association Vail presented his views in a forthright manner and optometric leadership everywhere will give his proposals serious study.

CAREL C. KOCH

TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data, news, professional problems and ideals, as these relate to the Academy.

LOCAL CHAPTER ACTIVITIES

EASTERN PENNSYLVANIA

Dr. I. Kaplan, professor of anatomy at the Pennsylvania State College of Optometry, and Dr. J. F. Neumueller, professor of optometry at the Pennsylvania State College of Optometry, were guest speakers at recent meetings of the chapter. Dr. Kaplan talked on eye operations; Dr. Neumueller on the principles of the space eikonometer.

INDIANA

1951 officers elected by the Indiana Chapter are Dr. Kenneth Kintner, Mishawaka, president; Dr. Virgil McCleary, Warsaw, president elect; Dr. Russel Reed, LaPorte, vice president; Dr. I. M. Borish, Kokomo, secretary-treasurer. Executive council: Dr. Robert Tubesing, Richmond; Dr. Dan Elliott, Jr., South Bend; Dr. Robert Ledig, Indianapolis.

SOUTHERN CALIFORNIA

Southern California chapter members met February 9 to hear the report of delegates to the annual meeting of the American Academy of Optometry in Chicago.

NEW JERSEY

Officers elected to serve the New Jersey chapter in the coming months are Dr. John R. Wittekind, Morrisville, Pennsylvania, chairman; Dr. Philip Jackman, Hackensack, vice chairman; George M. McEneany, Asbury Park, secretary, and Herbert L. Ratliff, New Brunswick, treasurer. Executive board members: the officers, and past chairman Dr. Harold Simmerman, Woodbury.

ILLINOIS

Elections were held February 24 for the Illinois chapter, with the following elected to officership for 1951: Dr. Willis Brown, Elgin, president; Dr. Don A. Frantz, DeKalb, vice president; Dr. Grace Stevesson, Chicago, secretary-treasurer. On the executive council are Dr. John Peterson, Rockford; Dr. Eugene Strawn, Rockford; Dr. T. R. Murroughs, Chicago, and Dr. Harley McCormack, Zion (past president).

CURRENT COMMENTS

Virginia Huck
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department; such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

GEORGE BERNARD SHAW

Almost every day, old stories about famed George Bernard Shaw are revived in our press, and occasionally a new biographical note crops up about the legendary playwright. Among the new stories is that of Dr. John Cole, British optometrist, who took care of G. B. S. for many years before his death. "G. B. S.: The Patient," appeared in the November 10, 1950, issue of *Dioptric News*, and reveals the more human side of the great author. Recalls Cole:

"When I first examined him (G. B. S.), he came to my rooms in his old Humber car. By that time, he himself had given up driving. I remember the occasion well. I had been expecting an overbearing person, difficult to handle, loth to spare time for the consultation and oozing superiority of intellect. Instead, I was confronted with a physically ailing man in the well-known Norfolk jacket, willing to

give me all the time I needed and to do precisely as I asked of him. He was patient and friendly and prepared to engage in consultation on my level. His symptoms he described with the same precision, economy and vividness of word as characterise his writings: and it all came out in his rich Irish burr.

"It proved necessary for me to prescribe for him, and in due course he came again to collect his new spectacles. His parting words were characteristic of his impish humour. 'Send me your account,' he said, 'and cash my cheque at once, for I am liable to die at any moment.'

"When next he needed my attention he had become too frail to travel to me, and I visited him at Shaw's Corner in Ayot St. Lawrence. I was received by Mrs. Laden, his housekeeper, whom I subsequently came to know well. She devoted herself to making G. B. S. comfortable in his last years and, through her efficient housekeeping and understanding management of him, succeeded to a degree that probably few others could have done.

"Whenever I went to see G. B. S. I always had to wait whilst he was found and fetched in. He would be wandering either in the grounds of his house or in the lanes about it: if the latter, he would have on the white mackintosh which was his own solution for the war-time blackout.

"The room in which he received me on my earlier visits was crammed with gifts from famous persons the world over. There were busts of him, pictures of him, photographs of him, and books by his contemporaries. He would come into this room and almost meekly sit down for me to do whatever I desired.

"I always had the impression that Shaw the man was an intrusion into this sanctum of Shaw the model. Indeed, probably because the representations were of younger Shaws, there was almost an air of ghostliness when G. B. S. himself came in.

"On later visits I used to see him in his living room. This was crammed with the impedimenta of Shaw the writer. Everywhere were cuttings, typescripts, books and everything conceivably connected with authorship. Although large, it was an exceedingly friendly and intimate room. One felt about it that here was the very core of G. B. S.'s material world.

"When his glasses needed repairing he would send them to me packed by himself and addressed to me in his own hand. Never once was it otherwise.

"I regard it as a great privilege to have represented my profession in the service of such a great and famous man."

SIGNS OF THE TIMES

Members of the New Jersey Optometric Association have been urged to join the Civil Air Patrol as eye consultants.

★

Portable first aid units for repairing G. I. spectacles broken in combat are being assembled by the American Optical Company. The units can be moved directly to the firing lines, if necessary.

★

The current hostile attitude of some few State optometric associations toward opticians has many leading opticians worried. These opticians point out that most of the friction between the groups is caused by anti-optometric advertising on the part of a few dispensers, yet all opticians are feeling the enmity. They hope for a satisfactory ending of these antagonisms.

★

Optometrists are underway with their plans for home front defense. The first four steps are being taken in many places. These are, (1) plans for the re-officing of optometrists by doubling up if necessary after attack: (2) arrange through all local laboratories for a steady flow of materials to all practitioners irrespective of loss of supply: (3) inventory lists of duplicate refracting room equipment in an area for future loan to disaster victims, and (4) duplicate sets of individual patient record charts in areas of safe keeping by each optometrist. State and local optometric societies are fronting up these home front defense programs.

MEETINGS AND SEMINARS

READING CONFERENCE

February—Teachers of the Northeastern Ohio area were again guests of the Northeastern Ohio Chapter of the American Academy of Optometry at a conference on reading problems February 24, in Cleveland. Featured speakers at this fourth annual conference were Dr. Helen Blair Sullivan, professor of education, and director of the educational clinic, Boston University, and Dr. Leland B. Jacobs, associate professor of education, Ohio State University. The two author-educators alternated on the one-day program with lectures on reading disability and its effect on child growth, balanced reading programs for child development, and reading skills.

SEMINAR

March—Seven optometrists discussed various phases of visual training at the recent educational seminar sponsored by the Los Angeles County Optometric Association in cooperation with the California

Optometric Association. At the meeting held March 18, at the Los Angeles College of Optometry, lectures were given by Drs. Homer H. Hendrickson, Temple City; O. Doyle Dannenberg, Escondido; Donald R. E. Waters, Santa Ana; Bruce D. Jaques, Los Angeles; Willis P. Campbell, San Jose; George S. Hamilton, Glendale, and Leslie W. Scown, Hollywood.

CONTACT LENS GRADUATE COURSE

March 24—April 2 are the dates for the graduate course in the fitting of contact lenses at Pennsylvania State College of Optometry. As previously, the enrollment is limited to 12.

NEW YORK MEETINGS

March—Three important meetings on visual care take place in New York the latter part of this month. The third meeting of the recently-organized National Interprofessional Committee on Eye Care, the annual meeting of the Better Vision Institute, and the annual conference of the National Society for the Prevention of Blindness will all be held between March 28-30 in New York City. The three-day N. S. P. B. program will cover the needs of the school child, eye research problems and progress, industrial vision, the government's role in the prevention of blindness, eye injuries from atomic attack, the prevention of blindness through voluntary effort and through groups, and visual problems of the aged.

MINNESOTA STATE OPTOMETRIC ASSOCIATION

March—The 51st annual meeting of the Minnesota State Optometric Association was held March 11-13 in St. Paul, with a program featuring lectures by Dr. Louis Jaques, Los Angeles, California; Dr. Carel Koch, Minneapolis; Dr. Rudolph Ehrenberg, Granite Falls, and Dr. John R. Kennedy, St. Paul. Among the subjects discussed by the speakers were interprofessional relations, pre-instrumentation tests, recent developments in optometric practice, aniseikonia, optometry's problem in relation to the military service, visual training and visual testing.

OCCUPATIONAL VISION CONFERENCE

April—The roster of outstanding speakers who will appear on the April 1-3 program of the A. O. A. occupational vision seminar at N. I. C. O. includes: Hedwig Kuhn, M. D., Hammond, Indiana, ophthalmologist and industrial vision specialist; Carl F. Shepard, O. D., Chicago optometrist, lecturer and author; Joseph Tiffin, Ph.D., professor of industrial psychology, Purdue University; John Marshall Ziv, Chicago consultant in color as related to efficiency and safety; Paul K. Fryer, specialist in occupational vision, Bureau of Visual Science, American Optical Company, Southbridge, Massachusetts, and Sylvester K.

Guth, electrical engineer in charge of lighting research, General Electric Company, Nela Park, Cleveland, Ohio.

EASTERN STATES OPTOMETRIC CONGRESS

April—The Eastern States Optometric Congress is scheduled this year for April 14, 15 and 16 at the Hotel Statler in New York City. In order to keep the program within the field of optometry as much as possible, no invitations were sent to non-optometrists, but optometrists planning to attend are allowed to invite personal guests. Scheduled to appear on the program are Dr. Harold Haynes, School of Optometry, Pacific University, Dr. A. M. Skeffington, Dr. Darrell Boyd Harmon, and Dr. Emmett Betts, Temple University. Workshop demonstrators include Drs. Lewis Kraskin, Edwin P. Leonard, Lester H. Sugarman, Robert Foster Ash, Richard McChesney, Daniel Woolf, Milton Chodroff, E. B. Forrest and M. E. Orgen. General chairman of the congress is Dr. N. A. Robbins, Buffalo, New York.

GREAT LAKES CONGRESS

May—Participants in the 1951 Great Lakes Optometric Congress program in Chicago May 6-8, will be the following: Dr. Emmett A. Betts, director, reading clinic, department of psychology, Temple University, Philadelphia; Dr. Edmund F. Richardson, Hollywood, California; Dr. Darrell Boyd Harmon, Austin, Texas; Dr. A. M. Skeffington, Dr. E. B. Alexander; Dr. Leo Manas, Chicago; Dr. Glenn H. Moore, Chicago.

A. O. A. CONGRESS

June—The annual Congress of the American Optometric Association is scheduled for June 24-27 at New Orleans, Louisiana. The convention committee are: Dr. Louise Gautreaux, general chairman; Dr. Margaret Poche, secretary; Dr. D. H. Hagans, treasurer; Dr. W. A. Poche, registration; Dr. C. D. LaBorde, hotel arrangements; Dr. O. J. Melvin, education and speakers; Dr. George Gautreaux, entertainment; Dr. Arnold Aasen, exhibits; Dr. S. R. Clay, transportation; Dr. Warren T. Reynolds, publicity; Mrs. S. R. Clay, woman's auxiliary; Dr. Sanford J. LaBorde, program. The educational program will be announced at a later date.

ALL CANADA CONGRESS

June—Canadian optometrists will get together for their first All Canada Congress in Winnipeg June 10, 11 and 12. The meeting will be held at the Fort Garry Hotel. The convention program will be announced soon.

BRITISH EXHIBITION

July—The "largest and most comprehensive trade exhibition of its kind" is now being planned by the British Ophthalmic Optical In-

dustry for London, July 16-20. Sir Alexander Fleming, discoverer of penicillin, will open the exhibition and will be guest of honor at the banquet. Between 90 and 100 firms will exhibit in the halls of the Royal Horticultural Society; demonstrations of new instruments, apparatus and techniques will take place; visits will be arranged to optical factories, training colleges, the London Refraction Hospital, and other places of interest, and a program of social events is being arranged. The show will come at the height of the Festival of Britain. A week prior to the exhibition (July 10-13) the British Optical Association is sponsoring an International Ophthalmic Optical Congress at King's College, University of London.

NEWS BRIEFS

Names in the news: Dr. Robert F. Kettenhofen, Pomona, California optometrist, was named "Young Man of 1950" by the Pomona Junior Chamber of Commerce. Mrs. Katherine Cleaver was recently inducted into the Keystone Club of the Continental Optical Company where she has been advertising manager since 1930. Keystone membership hinges on 20 years of service. Dr. John H. Dunnington (M.D.) director of the Institute of Ophthalmology of Presbyterian Hospital, New York, has been elected to the board of directors of the National Society for the Prevention of Blindness. Dr. Gilbert L. Hicks, 63, dean emeritus and a member of the Board of Trustees, Chicago College of Optometry, died February 15. . . . Dr. Joseph F. Montminy, Lowell, Massachusetts, has been chosen the new president of Massachusetts College of Optometry, to succeed the late Dr. Herman L. Klein, who passed away last January. Dr. Montminy has been a trustee of the College since 1946. . . . Soft-Lite has added a new straight-top bifocal to its line of lenses. . . . The first large-scale, scientifically controlled campaign for treating trachoma with new antibiotics is currently under way in several Eastern Mediterranean countries under the direction of the World Health Organization. Professor Giambattista Bietti of Parma University, Italy, one of the world's leading trachoma specialists, is in direct charge. . . . Therminon Lens Corporation announces a new test devised to enable optometrists to demonstrate the value of its absorption lens. The only equipment needed for the test, advise Therminon officials, is a Therminon plano lens, an unshaded 60 watt (or stronger) light, and a reading card. With these, it can be demonstrated that the two minute interval of glare-blindness caused by the light, can be reduced an average of 24.3 seconds by filtering the light through a Therminon lens. Therminon has conducted research with the test, results of which are now being released.

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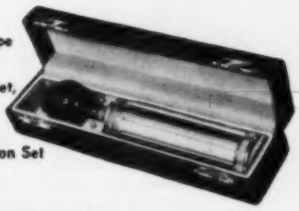

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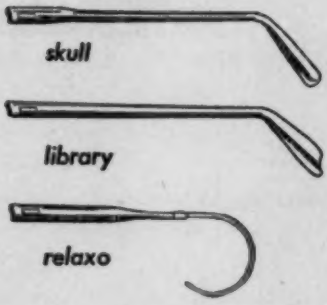

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